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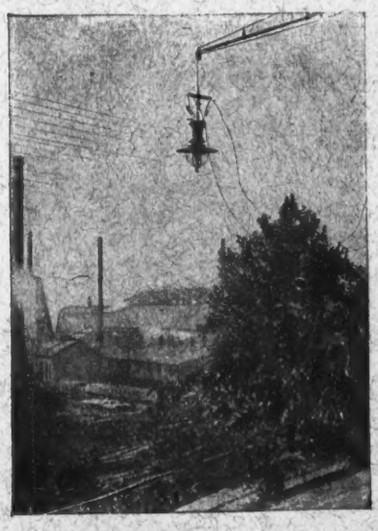

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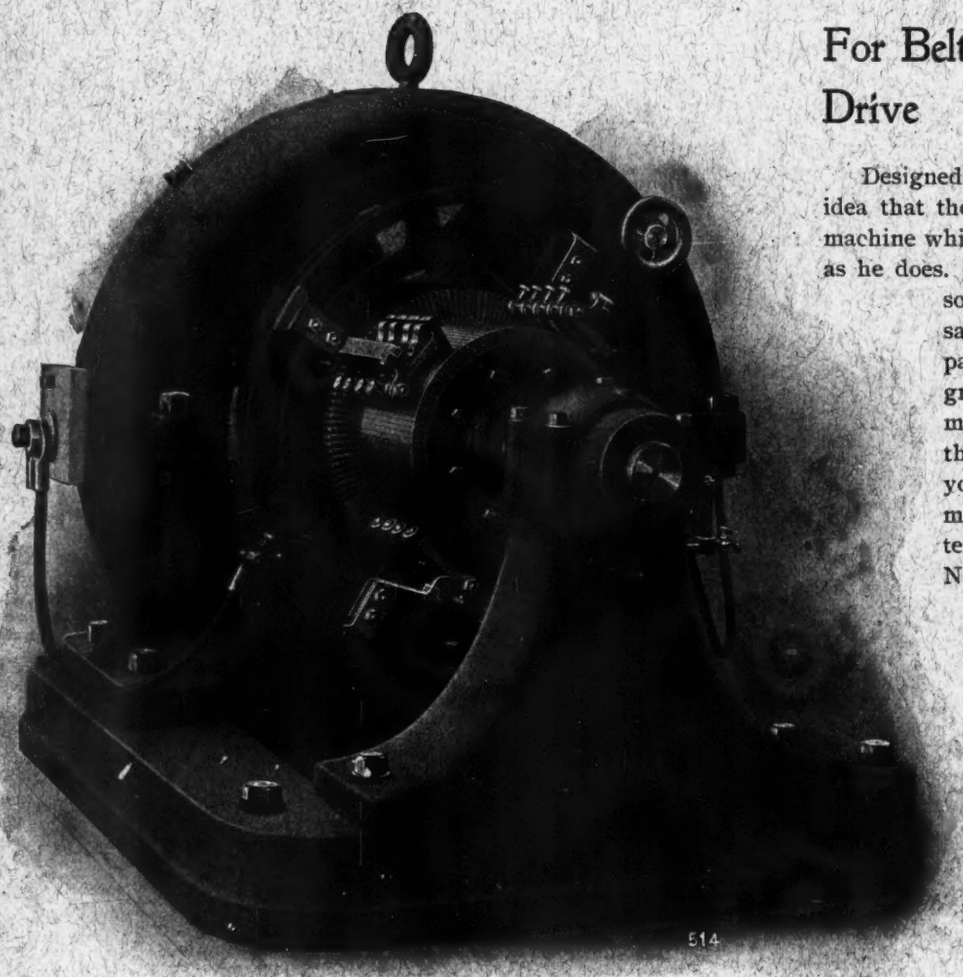

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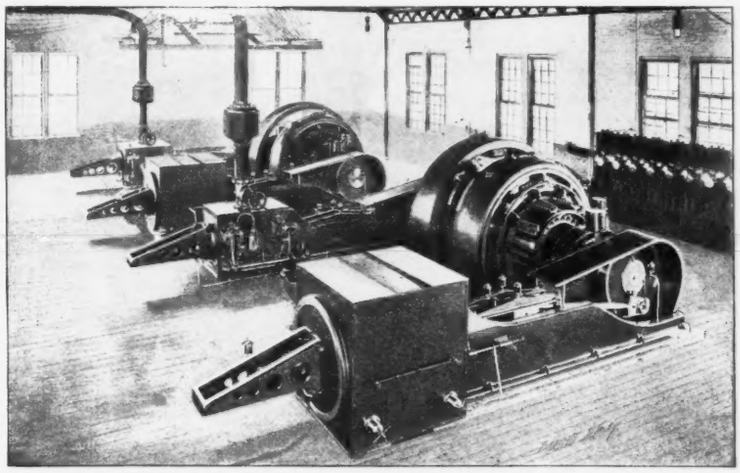

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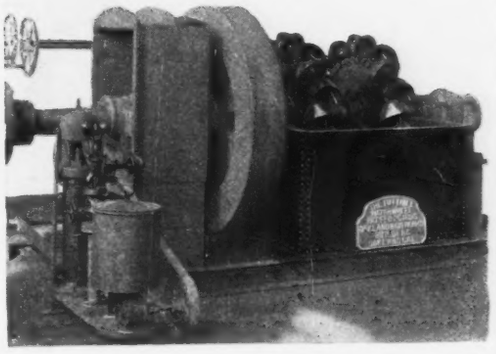

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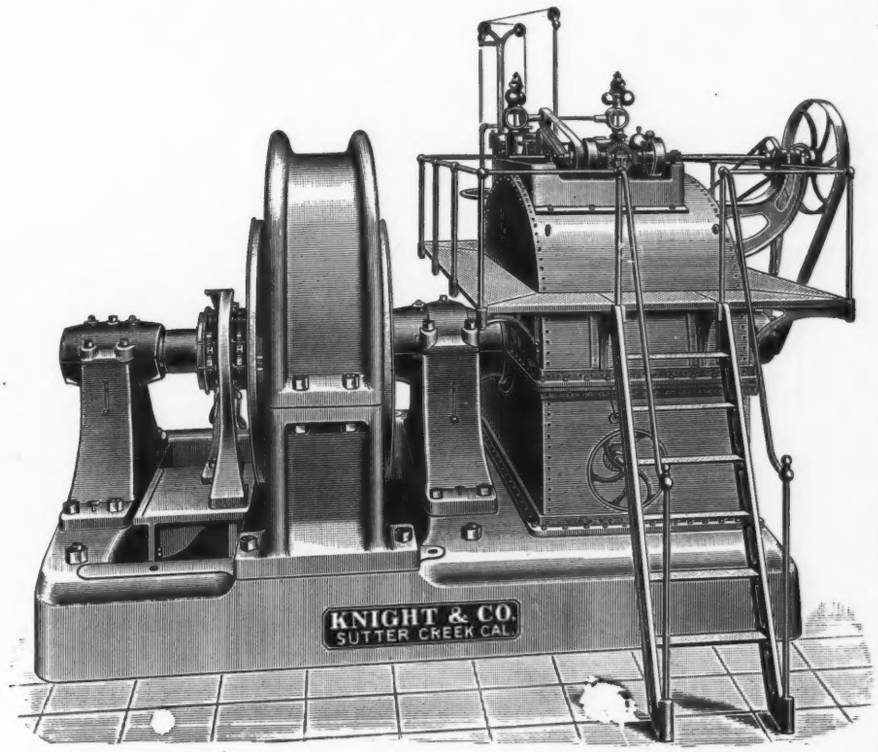

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The 50,000-Volt Transmission of the Missouri River Power Company.

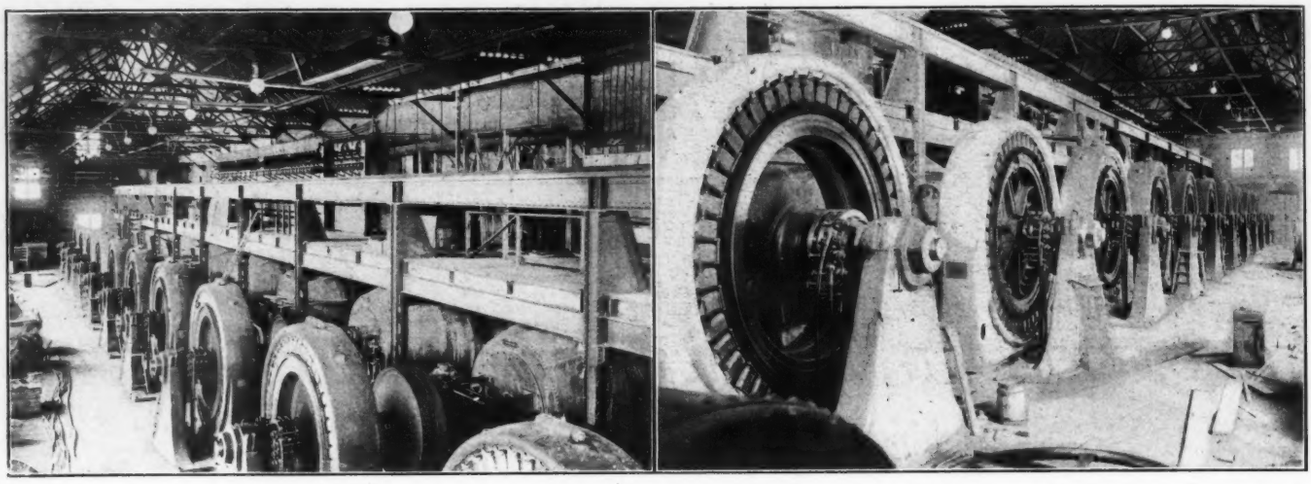
BY W. G. McCONNON.

ALTHOUGH several electric power transmissions have been proposed for the use of voltages higher than 40,000, the distinction of being the first to place in actual commercial service a large plant employing 50,000 volts in transmission belongs to the Missouri River Power Company. This installation was completed and the apparatus placed in operation about the first of March of the present year, and much credit is due to the general manager and engineer of the company, Mr. M. H. Gerry, Jr., who planned and executed the general undertakings, as well as to the Westinghouse Electric and Manufacturing Company, which furnished the electrical equipment. It is to be noted that since the starting of the plant there has been no mishap of any kind to the line or apparatus. This, the writer believes, is somewhat exceptional in undertakings of this magnitude and character, since it is generally expected that at the start minor difficulties are liable to be met with, which, though probably not serious, will nevertheless affect the continuous service of the plant.

A GENERAL VIEW OF THE POWER HOUSE, DAM AND SURROUNDINGS OF THE MISSOURI RIVER POWER COMPANY, CANYON FERRY, MONT.

The present power house of the Missouri River Power Company is located on the Missouri River about twenty miles almost directly east of Helena, Montana. To those who are familiar with the early history of the Northwest, it will be recalled that in the famous Lewis and Clarke expedition of 1803–4, up the Missouri River and across the continent to the Pacific, one of the resting places and points of interest spoken of is Black Rock Canyon, met with soon after entering the Rockies. Black Rock Canyon is not now known by this name, but at the mouth of the canyon lies the present little town of Canyon Ferry and the power house of the Missouri River Power Company. A general view of the power house and town is given as the initial illustration of this article, which shows them located in a country not as rough as some parts of the Rocky Mountain district, but by no means level. The district immediately about Canyon Ferry has been one of the famous gold mining camps of the West, the discovery of gold having been made there in 1863. Placer mining is the more common way in which mining has been carried on, and it can be seen today to a limited extent within a mile or so of the power house.

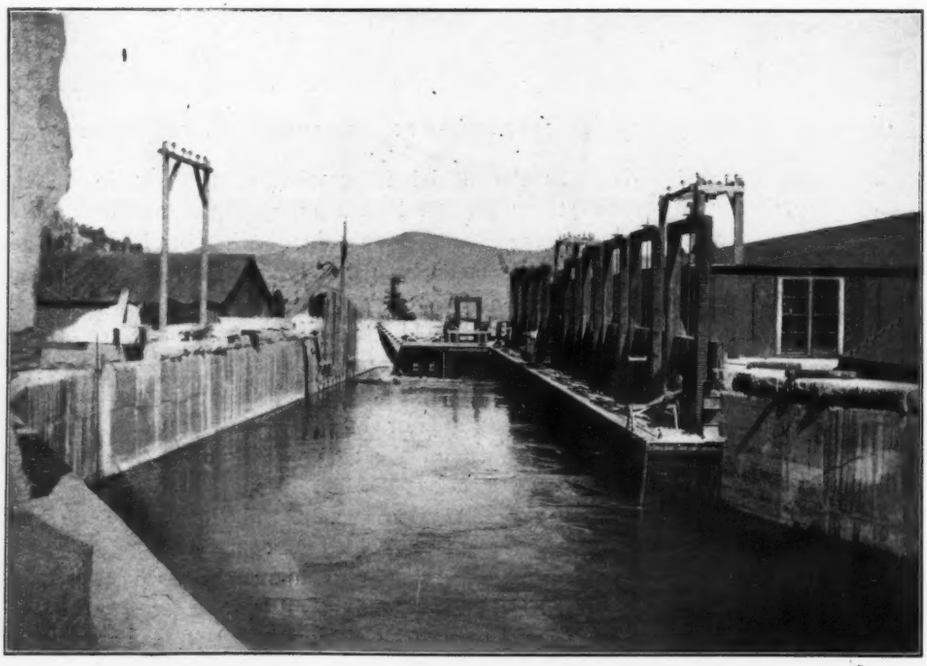
At the mouth of the canyon a dam has been thrown across the river about 460 feet in length and designed to give a thirty-foot head of water. The location of the dam at Canyon Ferry had enabled the company to take advantage of a low lying valley just above the entrance of the canyon in which to hold at all times a large volume of water in reserve. At the upper end of the canyon the water spreads out over this valley, forming a lake about



A GENERAL VIEW OF THE INTERIOR OF THE POWER HOUSE, INDICATING THE RELATIVE POSITIONS OF THE TEN GENERATORS, WATER WHEELS AND SWITCHBOARDS.

seven miles long by two to three miles wide. The canyon by which the water comes to the power house is from 300 feet to 400 feet wide and less than one-half mile long. The water in it does not freeze over in winter, and although the lake above freezes over, water flows to the power house as free from ice in winter as in summer. The amount of water in the river at this point is considered sufficient to develop 10,000 horsepower the year around.

The project for a power plant at Canyon Ferry was first started about ten years ago. The man who probably has taken a more continuous and extended interest in the proposition than anyone else is ex-Governor Hauser, one of the pioneers of Montana, and more thoroughly identified, probably, than any other living man with its history and interests. About four years ago the decision to carry out the work at Canyon Ferry took definite shape, and work was started on a plant of 4000 horsepower. This plant consisted of four 750-kilowatt, 550-volt, two-phase, Westinghouse generators, driven by a turbine variety of water wheels, with two 50-kilowatt exciters driven by independent wheels. The current from these generators was raised by eight oil-cooled transformers from 550 volts to 10,000 volts and sent to Helena and East Helena, twenty miles and fourteen miles away, respectively. At Helena the current was used after transformation to 2200 volts for driving induction motors direct-connected to arc light machines supplying city lights, and for distribution for general incandescent lighting. Two rotary converters furnishing current to the street car system of the city were also supplied. At East Helena the current was used mostly for driving induction motors in the large smelter located there and for general lighting about the works. One line from Canyon Ferry also furnished power and lights to a large ore concentrator, between Helena and East Helena, known as the Peck concentrator. The line between Canyon Ferry and Helena consists of but one pole line, carrying, however, four independent circuits, one to East Helena, one to the Peck concentrator and two to Helena, one of the latter for lighting and the other for railway work.



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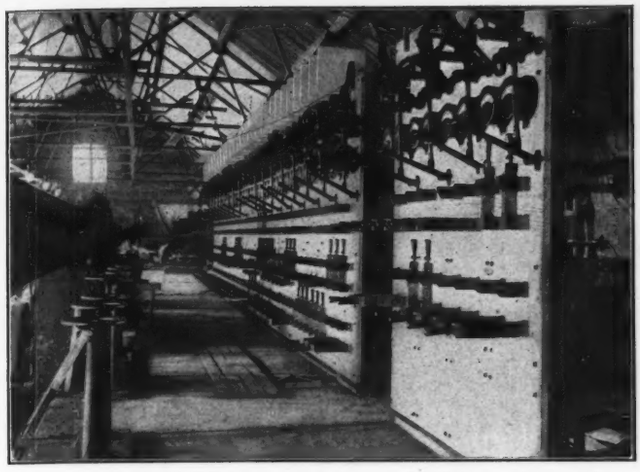
In the fall of 1900 work was begun at Canyon Ferry with a view of making a very considerable extension of the company's plant, the proposition being to enlarge the plant to a capacity of 10,000 horsepower by putting in additional generators, with exciters, transformers, etc., and to extend the service to Butte, Mont., where it was expected that all the power the company

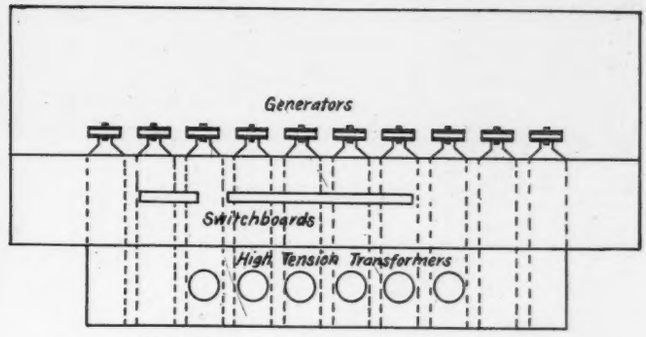


THE MAIN AND EXCITER SWITCHBOARDS, TAKEN FROM THE NORTH END OF SAME.

might furnish could be sold. To this end the company has installed six additional 750-kilowatt Westinghouse generators with the necessary transformers, exciters, etc. These generators are of the same size and voltage as the first four, but are three-phase instead of two-phase. The water wheels are forty-five-inch horizontal McCormack wheels furnished by S. Morgan Smith, of York, Pa. All generators in the power house are direct-connected to the wheels, flexible couplings being used throughout. With the new generators there was also installed a 225-kilowatt, 150-volt exciter, driven by a separate wheel, and a 115-kilowatt, 150-volt exciter driven by an induction motor.

To sum up, the power plant now consists of ten 750-kilowatt direct-connected generators, with four exciters, of which two are 50-kilowatt machines direct-connected to separate wheels, one a 225-kilowatt machine with a separate wheel and one a 115-kilowatt motor-driven generator. To make the plant uniform throughout, the four old generators have been overhauled and changed from two-phase to three-phase machines. The companion engravings on page 104 show the row of generators, those in the foreground of the left hand picture being new ones and the last four being old machines. The general plan of the station is shown by the accompanying outline sketch, the switchboard gallery being on the right and directly over the water wheels. Each water wheel has its own governor; all the new and one of the old wheels having Lombard governors.

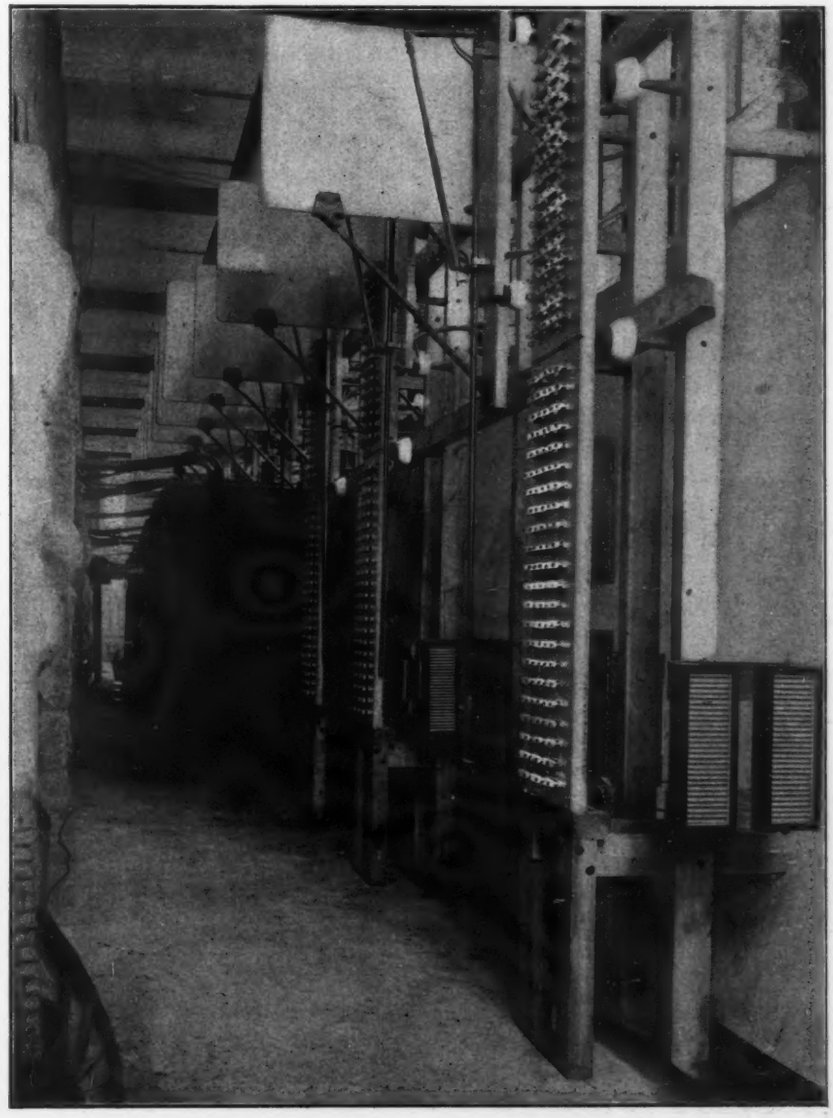
The switchboard gallery extends the whole length of the building, and, besides carrying the switchboards, carries also twelve 550 to 10,000-volt oil-cooled transformers for the Helena and East Helena service, as well as a plug-board for connecting these circuits as needed under various conditions. The offices of the company will be located on the floor extending across the building



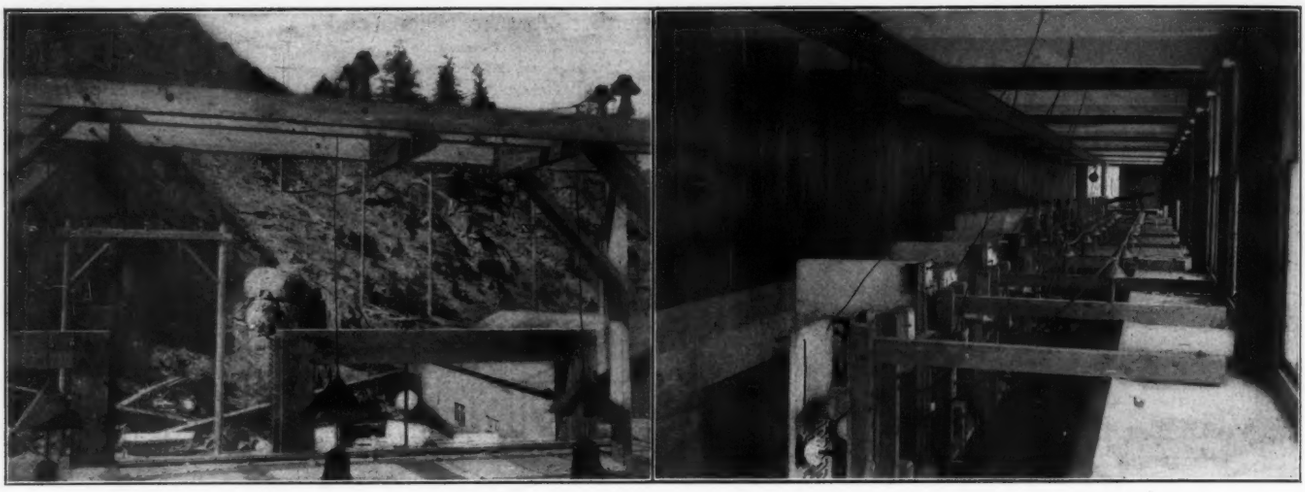
GENERAL PLAN OF THE POWER HOUSE AT CANYON FERRY.

at the end from which the left hand one of the companion views is taken.

The main switchboards and exciter switchboard shown in the cuts are both relatively simple boards in design, but



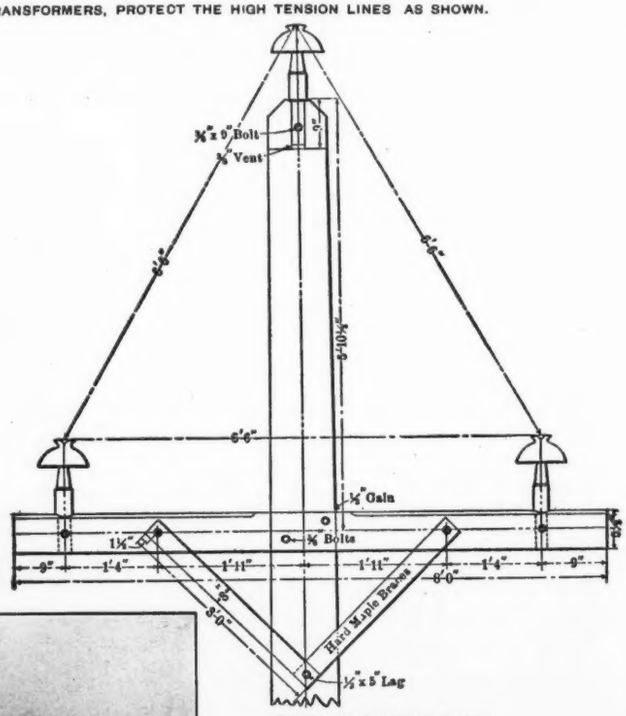
THE HIGH TENSION 50,000-VOLT TRANSFORMER ROOM, SHOWING TRANSFORMERS, LIGHTNING ARRESTERS, HIGH TENSION SWITCHES, BARRIERS, ETC.



SHOWING THE HIGH TENSION BUSSES AND THE METHOD OF ENTERING THE BUILDING WITH THE HIGH TENSION WIRES THROUGH THE ROOF. IN LEAVING THE BUILDING LONG GLASS TUBES, SIMILAR TO THOSE USED IN TRANSFORMERS, PROTECT THE HIGH TENSION LINES AS SHOWN.

massive and substantial in construction. The main board is forty-seven feet four inches long and consists of seventeen panels of blue Vermont marble two inches thick. The weight of the board complete is about twenty tons, the copper alone being one-half of this weight. The general arrangement is as follows:

The first five panels at each end are generator panels. The next two panels are feeder panels and are intended for use with the 550- to 10,000-volt transformers. The eighth panel from the end on each side supplies a bank of transformers (550 to 50,000 volts) for the Butte lines. The middle panel is a junction panel, so that any set of busbars on the two ends of the boards can be thrown together, there being three sets of busbars on each end of a board. The instruments mounted on the board consist of eight 750-volt alternating current voltmeters, one for each set of busses and one at each end for the machines,



POLE TOP, MISSOURI RIVER POWER COMPANY.

THE TWO LINES ON THE LEFT ARE THE LINES TO BUTTE, OPERATING AT 50,000 VOLTS. THE TWELVE-WIRE LINE ON THE RIGHT IS THE 10,000-VOLT LINE TO HELENA.

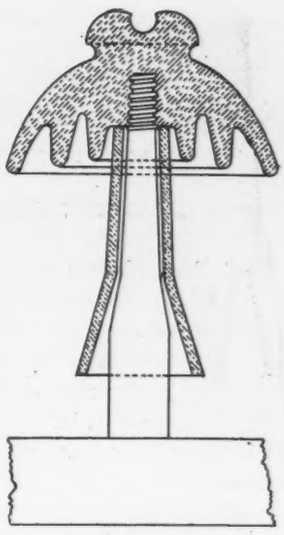
independently of the busses; ten direct-current field ammeters; twenty-eight alternating current ammeters, with sixteen indicating polyphase wattmeters, and six recording polyphase wattmeters. The recording wattmeters are behind the board. The exciter board consists of four panels of blue Vermont marble, similar to the main board, one for each exciter, with two sets of busbars. All field rheostats are mounted under the gallery floor and are controlled by hand wheels, the shafts of which come up through pedestals in front of the boards.

The feature distinguishing the Missouri River Power Company's plant from all other transmission plants is the high voltage employed on its new lines to Butte. This is 50,000 volts, which is higher than is in use commercially on any other plant at the present time. The distance by pole line from Canyon Ferry to the Butte substation is sixty-five miles, the route corresponding nearly with that taken by the Great Northern Railroad between East Helena and Butte. The line starts out at an altitude of about 4000 feet above sea level at Canyon Ferry and gradually rises until it reaches an altitude of 7300 feet where it passes over the great divide a few miles east of Butte.

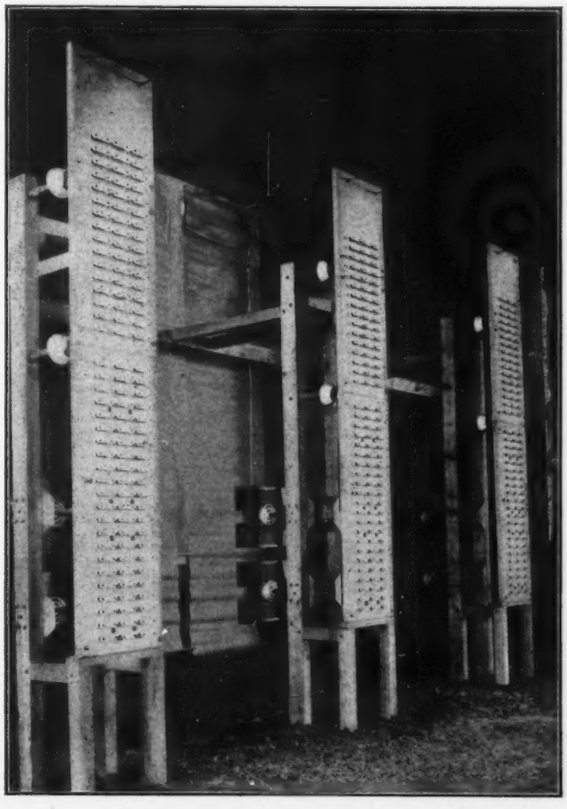
The line itself consists of two lines of poles about fifty feet apart, the cables being arranged in an equilateral triangle, with a spacing of seventy-eight inches between centers, as shown in the sketch illustrating the pole head. Each line consists of three seven-strand copper cables, each cable having a cross section of slightly over 106,000 circular mils. These cables are transposed five times between Canyon Ferry and Butte. The average distance apart of the poles is 110 feet. Accompanying this is given a view and cross section of the insulator used on the line, together with the glass sleeve fitting over the pin below the insulator. It has been found, after making exhaustive tests, that a thoroughly dry oak pin of the length used in this installation, boiled in paraffine, will readily hold up alone under 50,000 volts. Hence the object of the glass sleeve below the insulator is to keep as great a length as possible of the pin dry under all conditions of weather.

As has been pointed out by an eminent writer* the substitution of hardwood for iron cross-arms in the pole line construction considerably increases the insulation resistance at the pole head, for leakage is determined by the distance by way of the cross-arm rather than through air.

The transformers at each end of the line consist of six 950-kilowatt oil-insulated transformers with water cooling coils in the cases. Those at Canyon Ferry transform from 550 to 50,000 volts, and at Butte the step down transformation is made from 50,000 to 2200 volts. The secondary circuits at Butte consist of 600,000-circular mil bare copper wire.



THE INSULATOR.

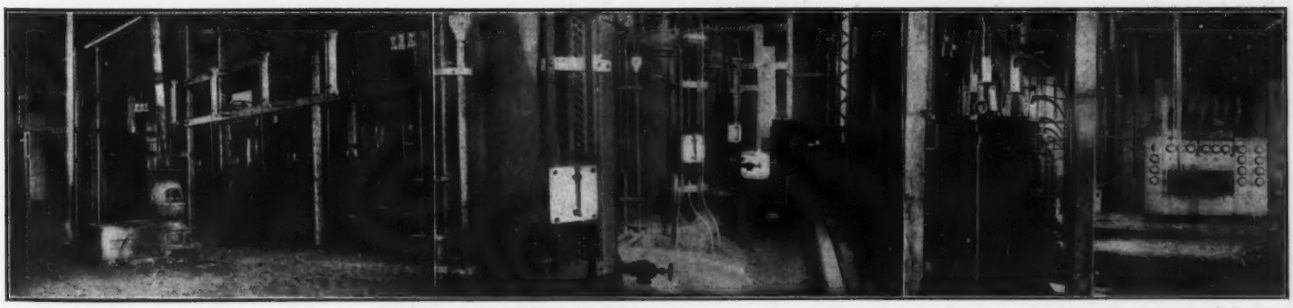


THE STATIC INTERRUPTERS.

Thus it is that the Missouri River Power Company holds the world's record as using in regular commercial service the highest transmission voltage. The Provo-Mercur transmission line* of the Telluride Power Transmission Company has been in highly successful operation in Utah since the spring of 1898, and as the load on the circuits of the great transmission lines of the Bay Counties Power Company has increased, the initial voltage at the Colgate power house has been gradually raised until now it is being operated at a potential of 45,000 volts, giving the Missouri River Power Company the distinction stated by some 50,000 volts.

*Louis Bell's "Electric Power Transmission," third edition, page 603.

*THE JOURNAL, Volume V, page 167, June, 1898.



SHOWING ESPECIALLY STATIC INTERRUPTERS, HIGH TENSION SWITCHES.

A BANK OF TRANSFORMERS, WITH CABLES AND WATER CONNECTIONS.

THE LOW TENSION VOLT 2000-SWITCHBOARD.

FOUR VIEWS OF THE INTERIOR OF THE BTTTE SUBSTATION OF THE MISSOURI RIVER POWER COMPANY.

Some of the Convention Papers.

Six of the Ten Important Papers to be Presented Before the Sixth Annual Meeting of the Pacific Coast Electric Transmission Association at San Francisco, June 17 and 18, 1902.

SURGES IN TRANSMISSION CIRCUITS.

BY F. G. BAUM.

A PAPER was presented by Mr. C. P. Steinmetz at the Annual Meeting of the American Institute of Electrical Engineers a year ago, discussing the subject of the causes and probable effects of the rise in potential over transmission circuits, but the paper was remarkably mathematical, and for that reason probably did not receive the attention it deserved. The subject has since been discussed by Dr. Kennelly* and by Mr. Percy H. Thomas.† These men are to be congratulated on their clear line of reasoning.

The subject is an interesting one to us, as we have all seen lightning arresters fused on account of the sudden opening of a circuit. I shall attempt to put the matter as briefly as possible, and in such a form that the rise in potential which we may get under the worst conditions may be easily and quickly determined. Three cases will be discussed:

1. Opening a line under a load or short circuit.
2. Closing a high potential line switch to charge the line.
3. Opening a high potential line switch to "deaden" the line.

(a) Opening a Line Under Load or Short Circuit.—Let us consider the case of a long line with a receiver load concentrated at the end. The line capacity will be assumed equivalent to a single capacity at the center of the line. We will consider one leg of a three phase system. The self-induction of one wire from the generator to the center of the line, that is, up to the capacity, is L, and the capacity of the entire line as a condenser is C (C is the capacity between one line wire and neutral). A current, I, flows over the line and is suddenly interrupted. As is well known, the energy stored up in the magnetic field (due to the current I), between the generator and the center of line is $LI^2/_2$. If the current is suddenly interrupted, this energy must flow into line condenser, since their is no other outlet. (It should be noticed that when the receiver is opened the line condenser is in series with one-half the line and the generator). If V is the resulting potential across the line condenser, the energy stored up in the condenser is $CV^2/_2$. But this is the same amount of energy which was previously stored in the magnetic field, neglecting the small loss due to the current flowing over the line resistance in flowing over the line into the condensor. Therefore,

$$LI^2/_2 = CV^2/_2, \text{ or}$$

$$I = V\sqrt{C/L} = VC\left(\frac{1}{\sqrt{LC}}\right) \qquad (1)$$

The current produced in a condenser of capacity C by an electromotive force having a frequency F is equal to (Applied electromotive force) $\times C\,2\pi F$.

Comparing terms with (1) we see that $\frac{1}{\sqrt{LC}} = 2\pi F$, in which F is the frequency of the current in the condenser. (1) may therefore be written

$$I = VC\,2\pi F, \qquad (2)$$

in which F is the natural periodicity of one-half the line. What really happens then when we interrupt the current I, is that the same current, having its natural outlet cut off, flows into the line condenser and charges the line. But the line condenser cannot remain charged, and, therefore, the condenser discharges again into the line self-induction, and the energy again is in the form of magnetic energy. The magnetic field, then, again breaks down, giving up its energy to the capacity and the whole cycle is gone over again and again, until the resistance of the line consumes the energy originally stored in the line self-induction. The frequency of the give-and-take of energy between the capacity and line self-induction is determined by the natural periodicity of the circuit F. The frequency F in the equation (2) is therefore the frequency of the current I, after this current has been interrupted at the receiver. If the circuit is working normally at a frequency f, the current I changes from a frequency f to a current of frequency F, that is, from the normal impressed period to the natural period of the circuit.

The natural periodicity of a circuit may be easily found from the equation

$$2\pi F = 1/\sqrt{LC}, \text{ or}$$

$$F = 1/2\pi\sqrt{LC}. \qquad (3)$$

For a three-phase transmission line we may take the self-induction for one-half line, for one wire, as .08 henries per hundred miles, or $L = .08\,H$, H being the length of line in hundred miles. C may be taken as two microfarads per hundred miles, or $C = 2H/10^6$ farads. Substituting for C and L in equation (3), gives us approximately

$$F = 400/H. \qquad (4)$$

(This frequency will not differ much for different distances between wires, because an increase in the distance will increase L and decrease C, the product remaining nearly the same. The same is true for different sizes of wire.)

That is, a line 100 miles long has a natural periodicity of about 400; a 200 mile line a periodicity of 200, etc. If we are operating normally at 60 cycles, a 200 mile line has a natural periodicity of little more than three times the frequency of operation.

From (2) we get the potential across the line condenser due to interrupting the current I equal to

$$V = I/C2\pi F. \qquad (5)$$

* "Surges in Transmission Circuits," by A. E. Kennelly, *Electrical World and Engineer*, November 23, 1901.

† "Static Strains in High Potential Circuits," by Percy H. Thomas, transactions of the American Institute of Electrical Engineers, February, 1902. Reprinted in THE JOURNAL, Volume XII, page 55 *et seq.*, March, 1902.

Substituting for C the value $2H/10^6$, and for F the value $400/H$, we get the simple equation

$$V = 200I \text{ (approximately)}. \qquad (6)$$

That is, the rise in potential is as a first approximation independent of the length of the line and equal to 200 times the interrupted current in amperes. If I is equal to 100 amperes (141 amperes maximum), and the current is interrupted when it has its maximum value, then

$$V = 28{,}200 \text{ volts} = 200 \times 100\sqrt{2}.$$

Interrupting 200 amperes would give us double this rise. This electromotive force will be superimposed on the line electromotive force, so the maximum strain possible for any interrupted current is

$$\text{Maximum strain} = E\sqrt{2} + 200\,I\sqrt{2}.$$

E is the voltage between line wire and neutral, and I is the current in amperes interrupted. It has been frequently noticed that a line having been short circuited, and the short circuit broken, the short circuit will frequently re-establish itself or a new short start at some other place between points across which the line voltage could not jump. The superposition of the oscillating electromotive force due to the removal of the short circuit to the line electromotive force is no doubt the explanation. We have assumed that the current is instantly interrupted. An arc will always be formed which will reduce the rise in potential.

On account of the inductive drop over the line, it is very probable that the current to be transmitted over one wire of a long distance transmission (100 to 200 miles) must be limited to about 100 amperes, unless the frequency is reduced below sixty. One hundred amperes, at sixty cycles, transmitted over a line 200 miles long gives us an inductive drop of about 50 per cent. with 50,000 volts between wires. The generators will probably deliver four times full load current as a maximum on short circuit. A short circuit in the center of the line would, therefore, give us about twice full load current, so that the maximum rise in potential due to the interruption of the short circuit would be about 56,000 volts. If the line is operating at 30,000 volts (equals 30,000 $\sqrt{2}$ maximum) between neutral and line wire the strain would be a little more than twice the normal. Under certain conditions a greater rise may take place.

In the above we have assumed a long trunk line with a receiver at the end. When the receiver current is interrupted, the line current is forced into the condenser. On our long lines, however, we usually have loads distributed along the entire length, and if there is a load on at different points the line discharges a portion of its energy into the local distributing circuits, and the rise in potential is therefore limited.

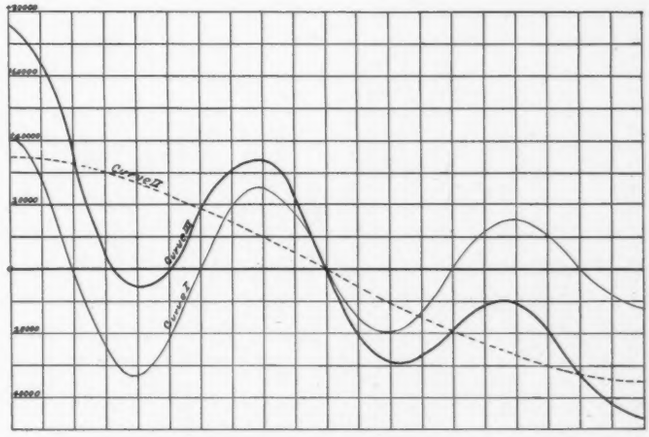
The amount of energy stored in one-half of a 100 mile line is quite small. For 200 amperes it is

$$LI^2/_2 = \frac{.08\,(200)^2}{2} = 1600 \text{ joules}.$$

That is, 1600 watts for one second. This amount of energy can be easily consumed by the local distributing systems and the line relieved of excessive strains. It is therefore important in a long line to have the loads distributed as much as possible, and then if we have even the worst condition of a short circuit no excessive rise in potential will probably take place.

(b) Closing a High Potential Line Switch.—On first closing a line switch on a dead line, a current will flow into the line condenser. But this current to reach the condenser must flow over the line self-induction, and energy will be stored in the magnetic field. This energy will then discharge into the condenser and add to the charge already in it. The maximum rise in potential is double normal working value.

(c) Opening Line Switch.—If we open a line switch to deaden the line we have the condenser of the line discharging at the periodicity of the line across the switch terminals the moment they are separated. Due to the charging current of the condenser the potential of the line rises to its maximum working value at the normal frequency of the circuit. Before the switch jaws can be separated very far, the line potential due to the oscillating current in the line will be superposed on the potential across the switch due to the generator. This may cause the arc to re-establish itself several times before the line



Showing oscillations of potential due to suddenly interrupting 150 amperes. Length of line about 130 miles. Line voltage 25,000 between neutral and line wire. Curve I, oscillations due to interrupted current. Curve II, generator impressed wave, 60 periods per second. Curve III, resultant line potential. Current is interrupted so as to produce maximum rise of potential.

is finally dead. The maximum possible rise in potential in this case is double normal working value.

We see from the above that the most dangerous condition is brought about when we suddenly open a short circuit. Curve I in the figure shows the oscillating potential due to interrupting 150 amperes on a line about 130 miles long. Curve II shows the generator potential. Curve III the resultant line potential.

The resultant potential, we see, is very much different from the impressed generator pressure. If, we continue to lengthen our lines until the natural periodicity of the circuit becomes nearly equal to the impressed periodicity it is very probable that we will have some new problems to solve. It may be that this will prove the determining factor which will limit the distance of transmission. It is intended to carry on some experimental work in this direction in the near future to determine, if possible, what new problems would have to be met if our lines should reach a length of from 400 to 1000 miles.

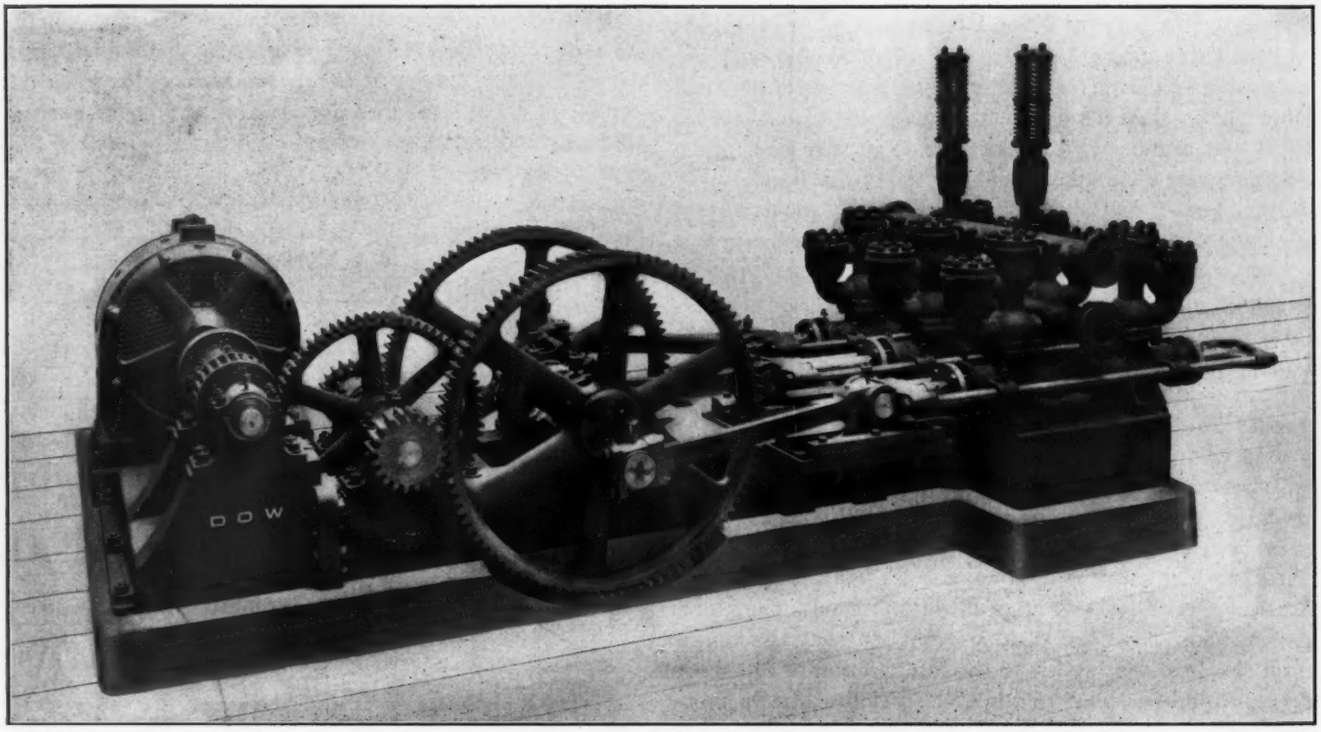
ELECTRIC PUMPING FROM A 1300-FOOT LEVEL.

BY DONALD H. FRY.

RECENTLY at the Oneida mine, situated in Amador County, an electrically driven pump has been installed at its 1300-foot level, a brief description of which, with a comparison of the costs of electric power and fuel oil, may be of interest. While a 1300-foot lift is "easy" compared to 2700 feet, as actually accomplished in Europe, nevertheless it is, as far as I am aware, the highest lift yet undertaken in California.

The pump is geared to a 100-horsepower Westinghouse 440-volt three-phase induction motor, running at 580 revolutions per minute, the current being conducted down the shaft in a lead covered steel armored cable, consisting of three No. 0000 wires, B. & S. gage. The line has been fused at two points—at the motor and at the top of the shaft, the latter fuses being of about double the carrying capacity of the former, to guard against the necessity of the pump man going to the top of the shaft to fuse up every time he has a hot box. The fuses at the motor are of just sufficient capacity so that in the event of any trouble they go out. A rawhide pinion on the motor drives the double set of gears on the pump, which is of the Dow horizontal triplex double plunger pot valve pattern. This machine operates at forty revolutions per minute, or 240 strokes per minute, the plungers being 4x16 inches stroke.

Most of the water of the mine is caught up at the 1250-foot level and run in a pipe to a dam in a special drift in the hanging wall on the 1300-foot level, which forms a reservoir capable of holding 70,000 gallons. A valve in the suction enables the motor to always start on the frictional load of the pump only. There is also a valve in a pipe which leads from the discharge back to the reservoir, and with this gate open and the suction also open the pump works against a one-foot head. On closing this second valve the pump takes the load gradually and without ram because of the slow action of this gate. A check valve prevents the column of water, when the pipe is full, from running back when the pump stops or from giving the motor a working load to start under. It takes ten minutes to fill the pipe. An inch valve above the check makes it possible to drain the pipe when necessary. All ram, due to the variable plunger speed, is taken up by two special plvngers acting against powerful springs.



DOW ELECTRIC TRIPLEX DOUBLE PLUNGER PUMP, CAPACITY 200 GALLONS PER MINUTE AGAINST A HEAD OF 1360 FEET, IN OPERATION AT THE ONEIDA MINE, JACKSON, CAL.

The pump lifts nineteen miners inches, or about 197½ gallons per minute, through a six-inch pipe to the surface, a vertical height of 1290 feet exclusive of friction, which I have calculated to be only five feet, including elbows, making a total lift of 1295 feet.

A test of the motor taken at the top of the shaft showed a consumption of 102 horsepower. This figure includes the lights and the cable loss. The actual power required at the motor is 98 horsepower. This gives an efficiency of 65¾ per cent. for the motor and pump.

Previous to installing the pump the mine used to lift the water in skips, 800 gallons per skip, yanked up at the speed of 2000 feet per minute. This took oil, and lots of it, but just how much could not, of course, be closely estimated until the pump and motor were installed. Now that this plant has been in use for two weeks a fairly

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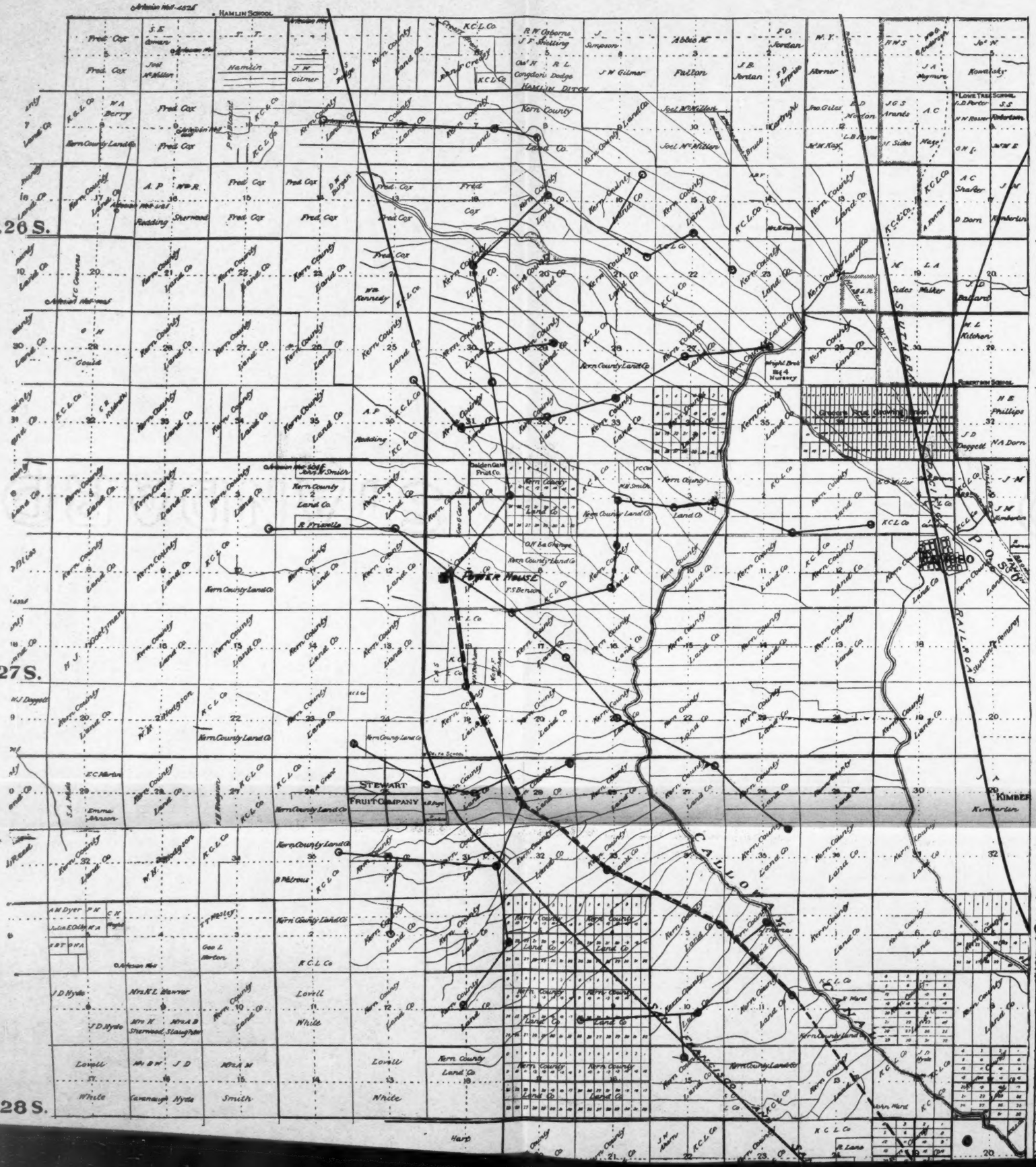
R.25E.

R.26E.

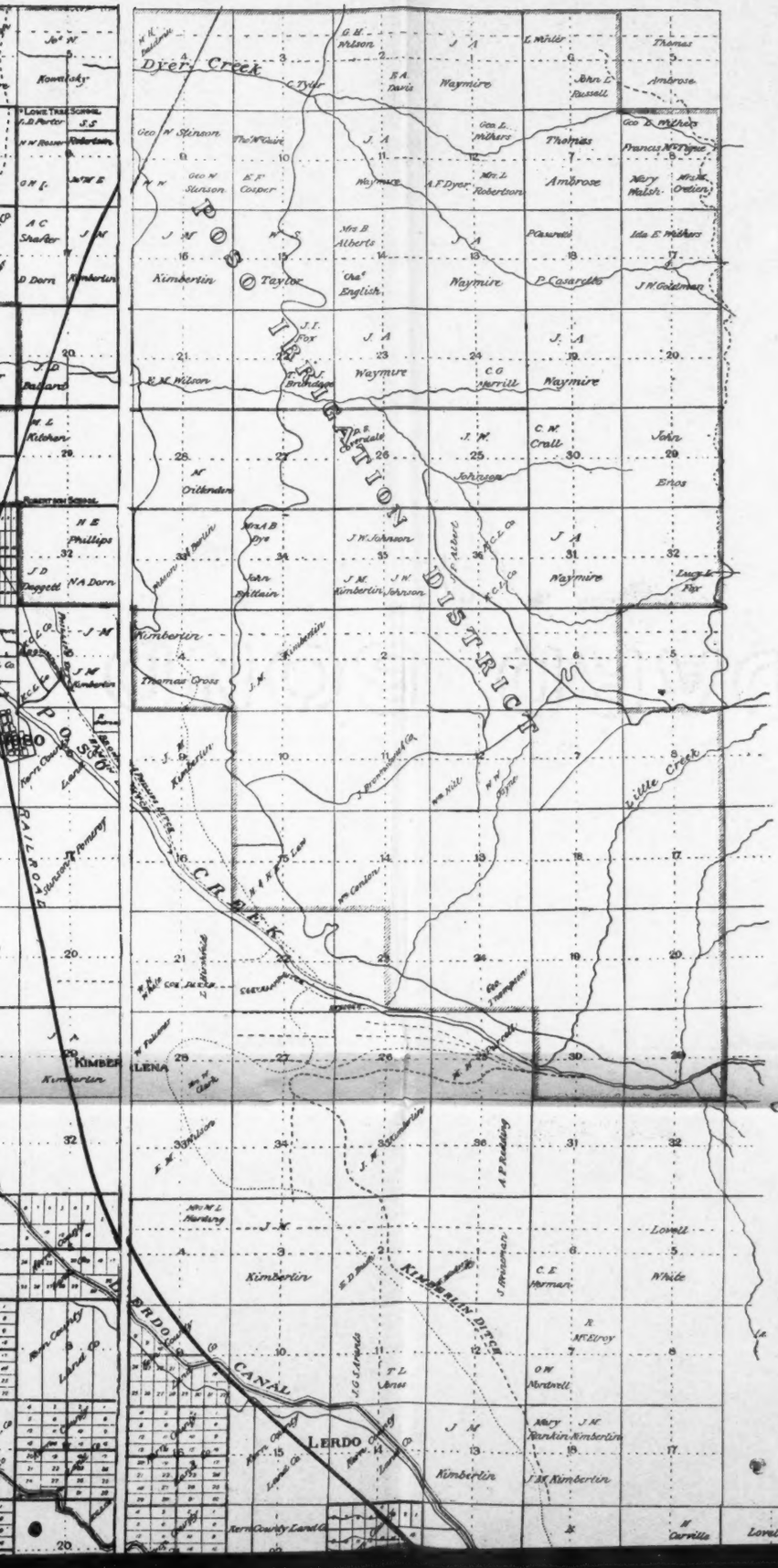
T.26 S.

T.27 S.

T.28 S.



R.26E.


Dyer Creek
IRRIGATION DISTRICT
C.R.I.&P.R.R.
KIMBERLIN DITCH
BRODIE CANAL
LERDO
KIMBER
LENA
RAILROAD

T.28 S.
T.30 S.
STEWART FRUIT COMPANY
KIMBERLENA
CALLOWAY CANAL
SAN FRANCISQUITO CANAL
BRIDGE CANAL
SOUTH
ROSEDALE
RIO BRAVO
RIO BRAVO VINEYARD CO.
OLNEY et al
WIBLE RANCH
PIONEER CANAL
HARBARGER CANAL
TRANSFORMER HOUSE
BUENA VISTA
Second Point of Measurement
Kern County Land Co.
K.C.L.Co

LERDO
CANAL
KIMBERLIN DITCH
JEWETTA
BEARDSLEY
CANAL
BAKERSFIELD
KERN
RIVER
COLONY
TOWNDALE
TRANSFORMER HOUSE
WILE ORCHARD
GOSFORD
Kern County Land Co
K.C.L.Co
Kimberlin
Lovell
White
Sherman
Flournoy
Breedlove
Wilson
East
Hodgett
Alex Kramer
J.E. Shafer
Mary Rankin Kimberlin
J.M. Kimberlin
C.E. Herman
O.W. Nordwall
T.L. Jones
J.G. Amends
J.S. Rogers
P.D. Jewett
Solomon Jewett
C.A. Maul
E.O. Stetson
T.E. Harding
H.A. Blodgett
N.F. Gibson
E.A. Taylor
R.E. Houghton
Kingsley N. Maxwell
C. Brown
Wible Ranch
G.J. Plantz
Alice Shannon
Ed. J.R. Nelson

R.24E.

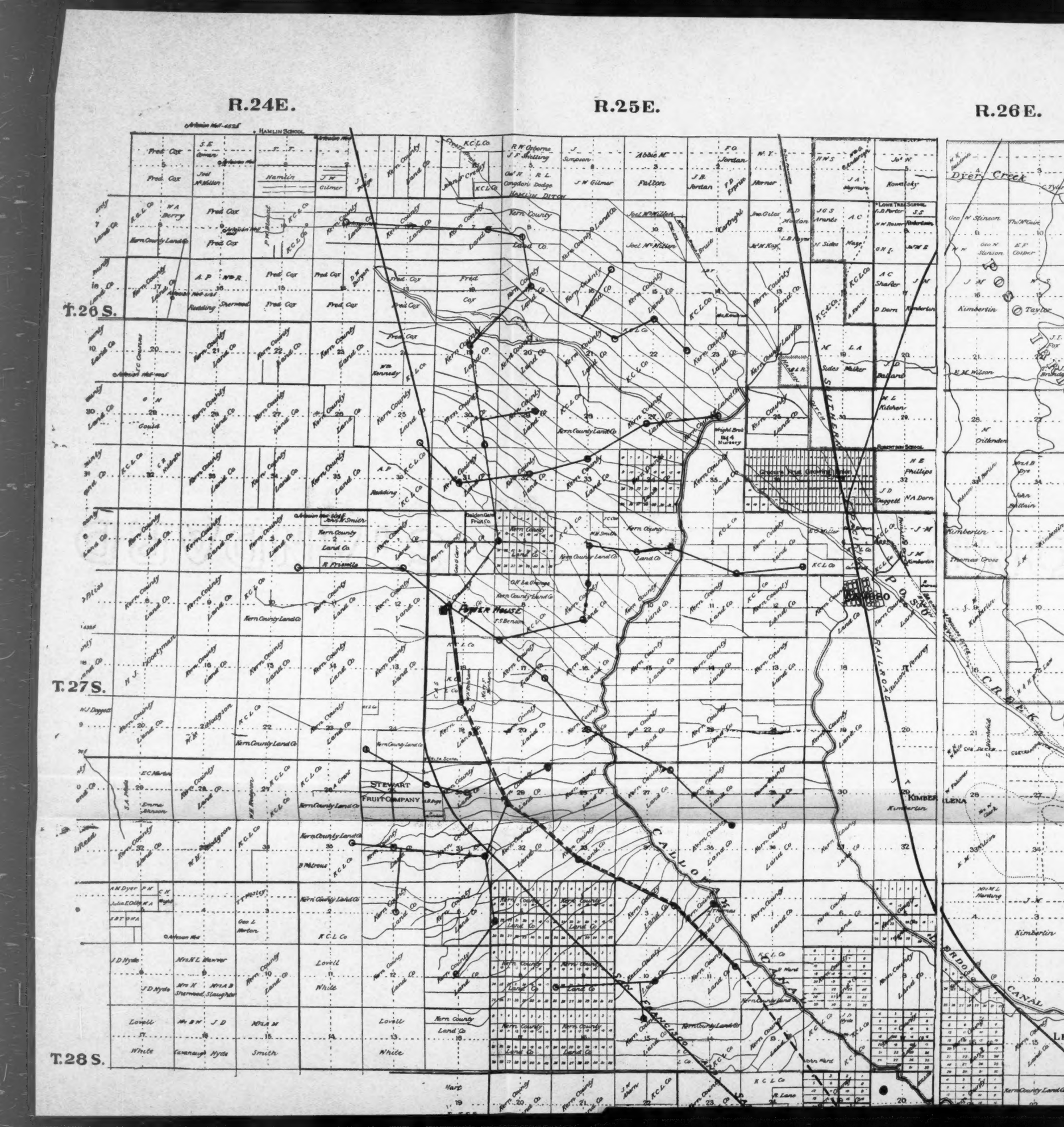
R.25E.

R.26E.

T.26 S.

T.27 S.

T.28 S.


HAMLIN SCHOOL
Hamlin
Fred Cox
S.E. Owen
Joel McMillen
J.W. Gilmer
Kern County Land Co.
K.C.L.Co.
Kern County Land Co
R.W. Osborne
J.F. Shutting
Cal. R.L. Congdon Dodge
HAMLIN DITCH
J. Simpson
J.W. Gilmer
Abbie M.
Fulton
J.B. Jordan
F.O. Jordan
FD Porter
Joel McMillen
Kern County Land Co.
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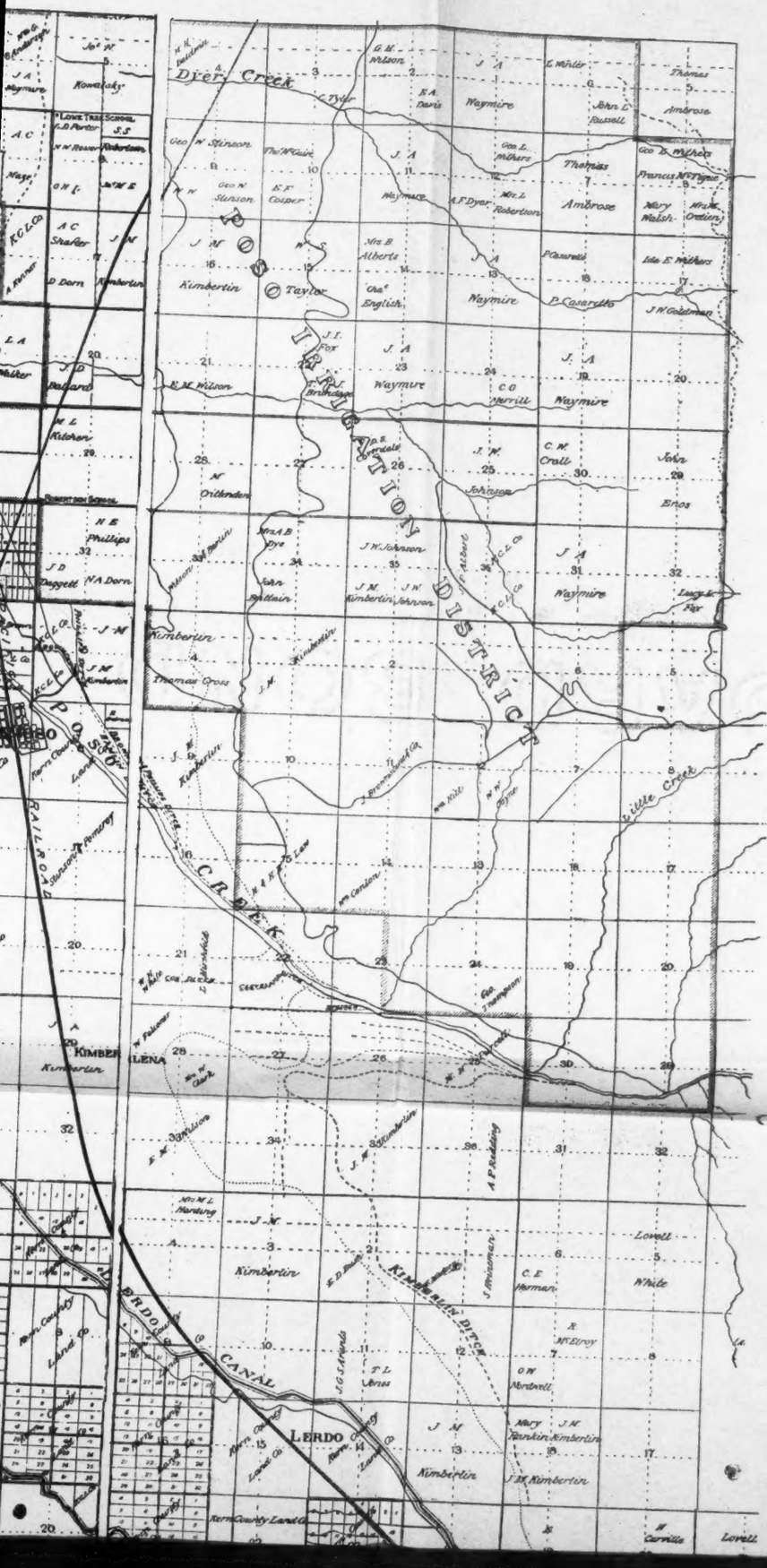
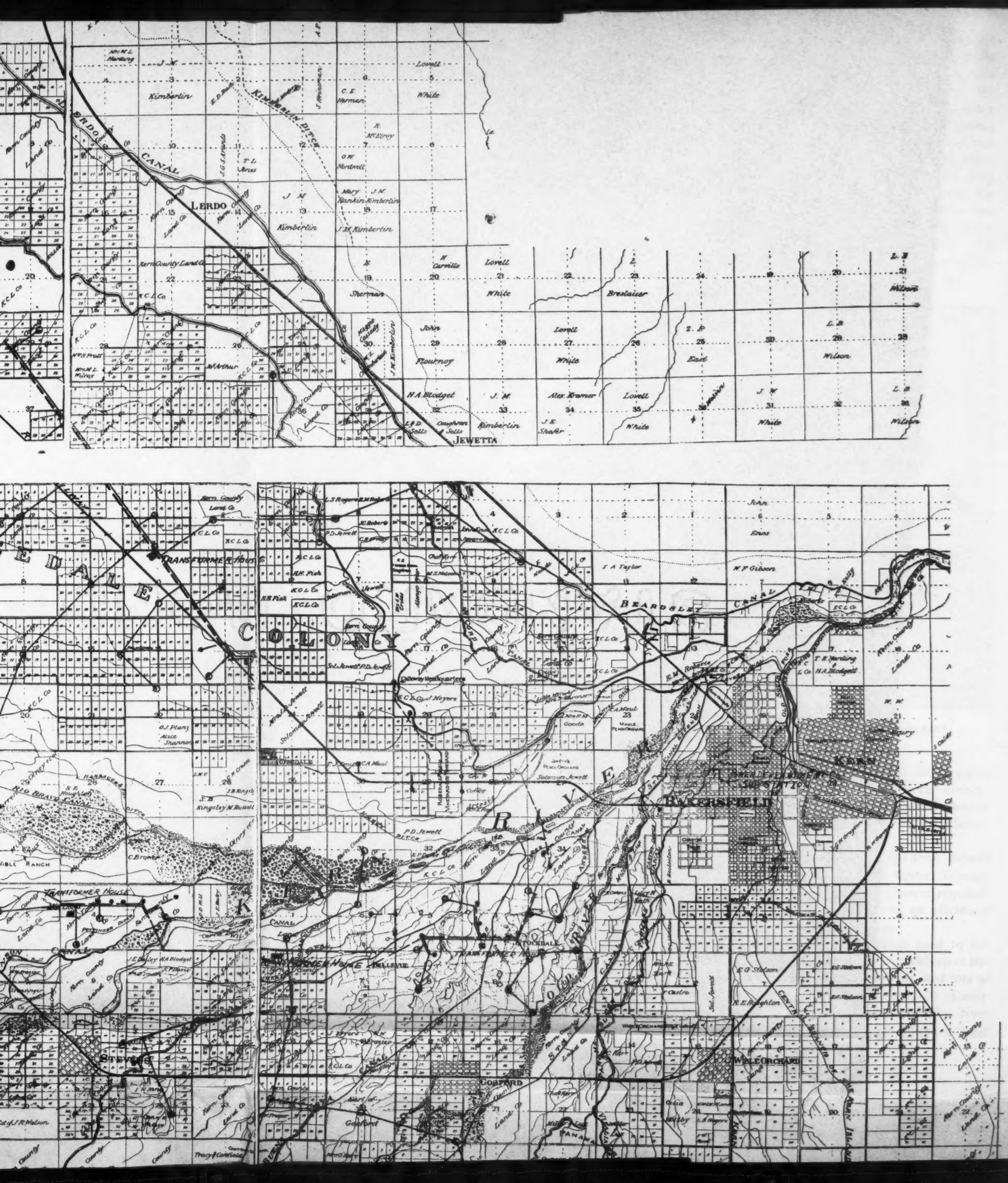
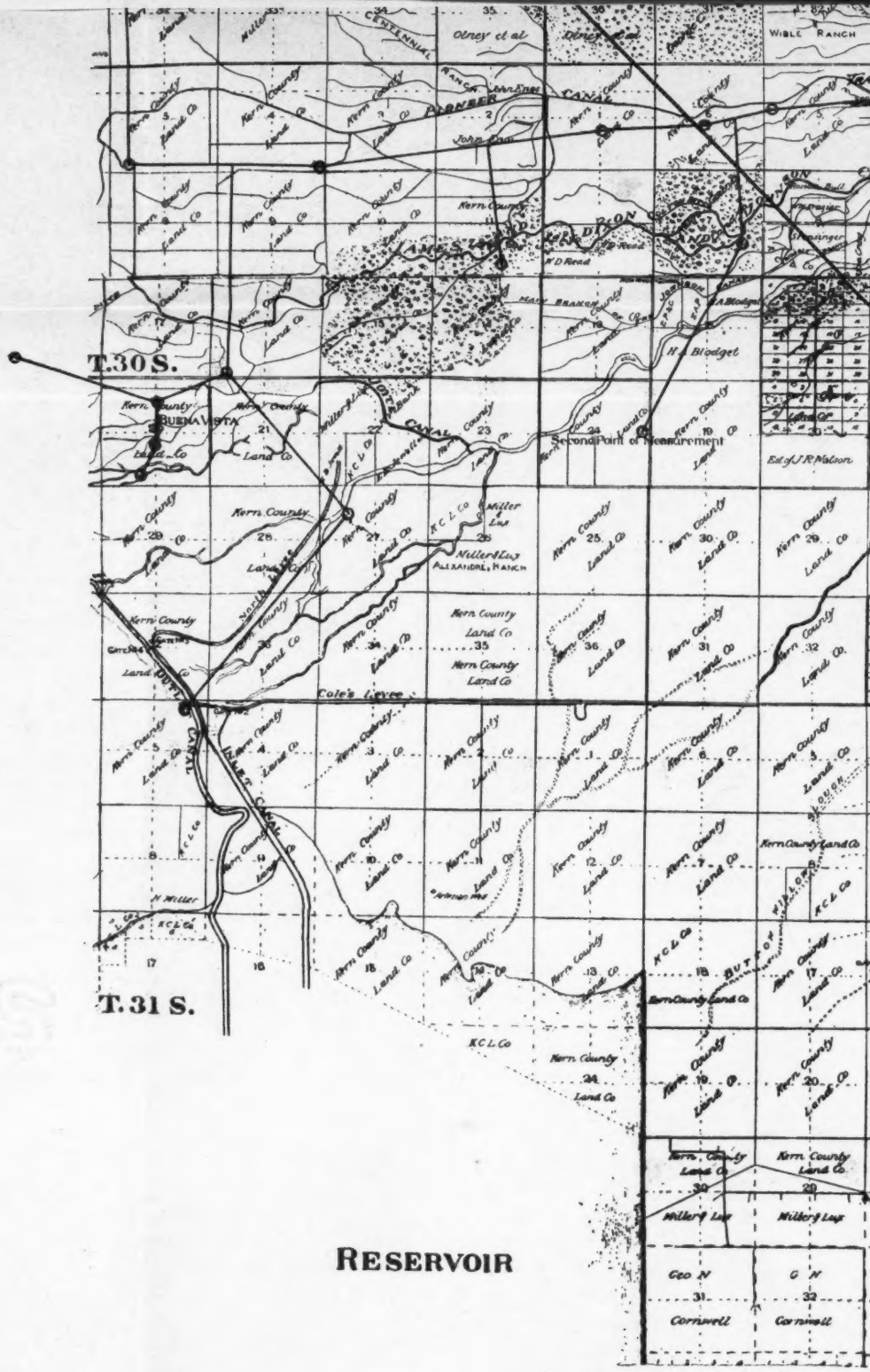
Kern County Land Co
Kern County Land Co

R.26E.


Dyer Creek
IRRIGATION DISTRICT
CREEK
CANAL
RAILROAD
LERDO
KIMBERLENA
Kimberlin
Waymire
Taylor
Thomas
Ambrose
Lowell
White
Johnson
Crall
Merrill
Robertson
Alberts
English
Casarotto
Dorn
Daggett
Phillips
Shafer
Packard
Thomas Cross
Little Creek

T.28 S.
T.30 S.
SOUTH
ROSEDALE
RIO BRAVO
RIO BRAVO VINEYARD CO
BUENA VISTA
CANAL
TRANSFORMER HOUSE
Second Point of Measurement

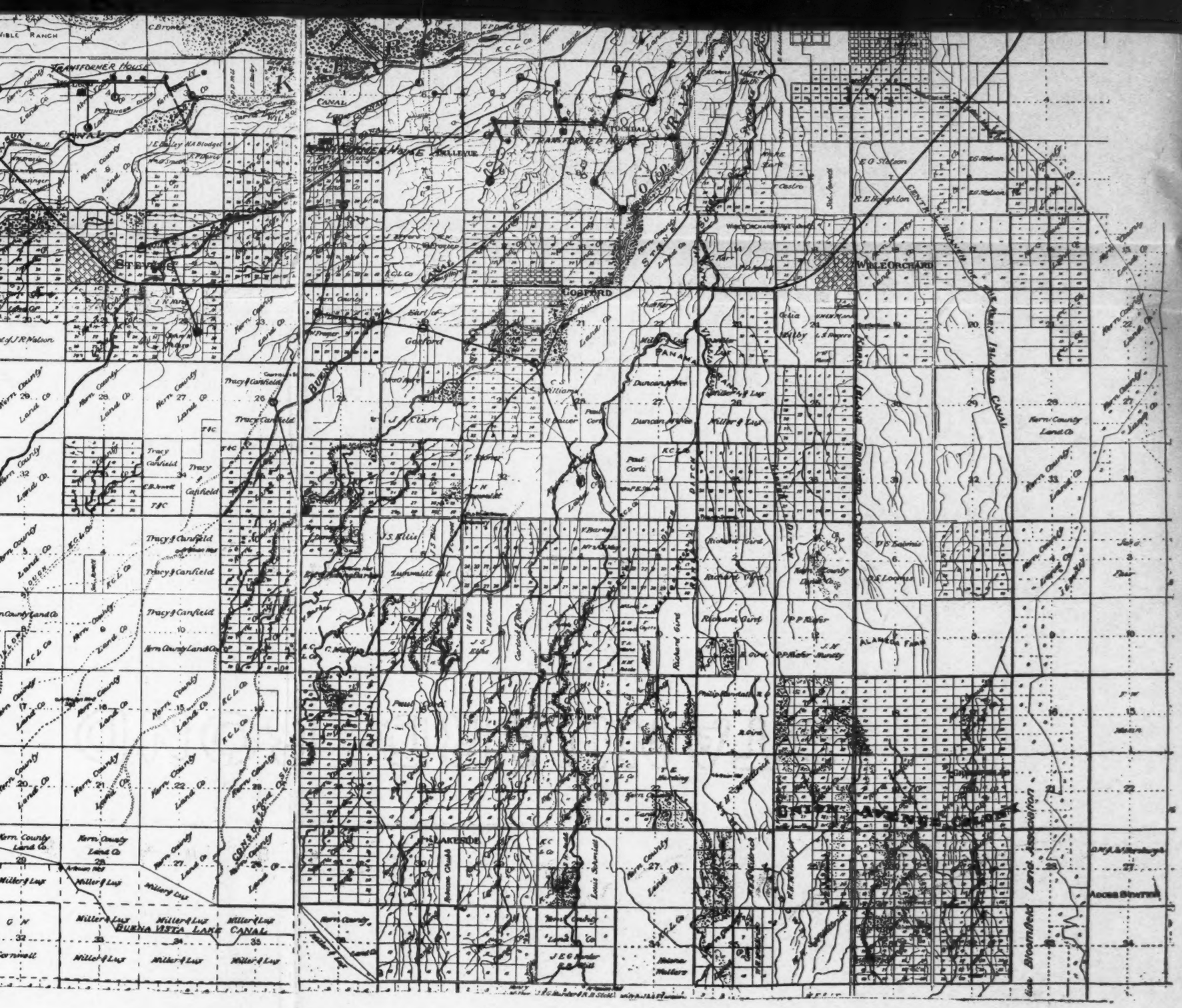

LERDO
JEWETTA
CANAL
Kimberlin
Lowell
White
Sherman
Flournoy
Wilson
East
Breslauer
Alex Romer
J. M. Kimberlin
H A Blodgett
Coughran & Sells
J E Shafer
L P D Stells
Kern County Land Co
K C L Co
TRANSFORMER HOUSE
BEARDSLEY CANAL
COLONY
RIVER
BAKERSFIELD
KERN
STOCKDALE
STEVENS
OSBORD
WILLOW ORCHARD
Solomon Jewett
P D Jewett
C A Maul
E G Stetson
R E Brighton
Goode
Meyers
Kingsley
Bronee
Graham
Hanna
Plans
Alice Shannon
Harmeier
Rio Bravo Canal
Transformer House
Pioneer Ditch
Main Canal
Cross Canal
Lateral
Ditch
Creek
Slough



3300-VOLT LINE.

● IRRIGATION PUMPING STATIONS AT P

PROPOSED POLE LINE FOR ELECTRIC C



— — — — — NEW 10,000-VOLT LINE.

NS AT PRESENT INSTALLED.

——— PRESENT 10,000-VOLT LINE.

O STOCK WELLS.

RIC OPERATION OF THE STOCK WELLS OF THE KERN COUNTY LAND COMPANY, KERN COUNTY, CAL.

approximate idea of the saving in oil can be obtained, though not until several months have passed will a careful study of the company's books reveal the exact saving.

During the two weeks previous to and the two weeks succeeding the installation of the pump the conditions at the mine were almost identical. The flow of water was, as nearly as can be calculated, the same; also the amount of rock hoisted was practically the same. More water has been pumped up from the 1300-foot level during the past two weeks than was bailed from that level during the previous two weeks, but the amount bailed from the sump at the 2000-foot level has decreased a corresponding amount—8000 gallons per day. This is due to the fact that the water skip tender used to allow a large percentage of the water to drop down the shaft by letting the tank overflow and by not shutting the gates properly. The saving of oil during the past two weeks has been 102 barrels, or 7.28 barrels per day. This amount at $1.50, the price paid for oil delivered at the mine, amounts to $10.92 saving per day, or about $330.00 per month. The electric power is used about four hours per day. Taking the power consumed as estimated from indicating instruments, or as calculated from the recording wattmeter, which registers all the power consumed at the mine, the cost of electricity will not exceed one-third the saving in oil. The price of oil is high, but that it could never compete with electricity is shown by the fact that the haulage on the extra oil consumed in order to bail the water is greater than the cost of pumping. This is assuring that future months will confirm the rather incomplete figures obtained during the past four weeks.

It might be well to mention another item of saving: that of wear and tear on the hoist—the heart of the mine, as it were. This saving more than compensates for the extra outlay in installing the pump. Especially is this true during the wet season, when the extra water may crowd the capacity of the hoist, and so cause some of the stamps to be hung up for lack of sufficient rock to keep the whole mill going. This means a reduction in income. There are cases where pumps could actually double the capacity of a shaft and hoist.

Water is still hoisted at the Oneida from the sump at the 2000-foot level, but it is the intention of the company, I believe, to install a second motor and pump at that level should a reasonable time prove the present installation a success.

Mr. Hampton, the superintendent of the Oneida Mine, has kindly given me invaluable assistance in obtaining the above figures.

PROPOSED ELECTRIC PUMPING FOR STOCK WELLS.

BY A. J. BOWIE, JR.

THE field for electric power has grown wonderfully in the last few years, and yet its possibilities and limitations are scarcely yet known. Everywhere it has been transplanting other means of power, forging ahead of all competition for general use. One of the extreme uses to which it might be successfully applied was in a plant proposed by the writer for the operation of the stock wells owned by the Kern County Land Company. The accompanying map shows the location of all these wells, and also the present line of the Power Development Company, which supplies power for the operation of the irrigation pumping plants where shown. These stock wells are of from six to seven and one-fourth inch casing and of depths varying from fifty to 150 feet. The distances from the surface of the ground to water, as measured after three successive dry years, was from ten to thirty feet in all but about four of the wells, where the depth of water was from forty-five to seventy feet.

The present installation at these wells consists of single acting deep well lift pumps, from three inches to four inches in diameter, with a maximum stroke of eighteen inches. The pump is put down the well and wooden plunger rods connect the same to a walking-beam, which is driven by a horsepower. A few of the pumps are provided with stuffing boxes in order to force water into tanks; but the majority of them have no stuffing boxes at all, as they deliver the water direct into the watering troughs. The average capacity of these troughs is about 300 gallons each. Most of them are of galvanized iron. At each well there are from two to eight troughs. A mule is used as the form of motive power, and a man or woman watches him and sees that everything goes well. In some of the places one attendant and mule can look out for several wells. Some of the wells have to be pumped continuously, however, so as to supply sufficient water for the stock. In all except the Poso Ranch, which includes all the pumps north of Rosedale, any or all of the pumps are liable to be used at any time. On Poso Ranch, however, of the seventy-five pumps, there are never more than thirty in operation at any one time.

The horsepower used consists of a large gear with internal teeth, mounted on a vertical pivot or shaft. This gear is driven by a projecting pole to which the mule is hitched. A pinion meshes with this gear, and drives through bevel gears a horizontal shaft, on the other end of which is mounted a fly-wheel and crank. The crank is provided with different holes for the crank-pin, so as to alter the length of stroke. Wooden rods connect the crank-pin with the walking-beam, which is also of wood. The average mule will pump from twenty to twenty-five gallons per minute with this rig in the wells of thirty feet lift. You have to keep after him all the time to keep him up to the twenty-five gallon rate, and twenty gallons is about a safe figure. Sometimes, when there is a great demand for water, it is necessary to keep pumping the wells continuously, night and day. Most of the time there is no other water near these wells, and the supply which is pumped is wholly depended on for drinking water for the cattle. It is, of course, absolutely essential that the cattle should not be without drinking water for any period of time, especially in the hot summer days. Should one pump break down so that it would take some time to fix it, the cattle would be driven into another field, where they could obtain water from another pump.

The maximum amount of water consumed by cattle on the hottest days, is twenty-five gallons per head per day. The greatest number of cattle ever watered from one well is 1200, corresponding to a total maximum demand of 30,000 gallons per day, or twenty-one gallons per minute, continuous pumping. Some of the pumps, however, supply only a comparatively small number of cattle, and are run only a small part of the time; others are often not run for long periods, depending for their operation on the way the cattle are moved into the different fields. The principal items of expense for the present operation of the wells, are the pay of the pump attendants, feed for the mules, and depreciation of machinery. The wages of that class of labor are naturally small, and feed is not high.

Such are the present conditions, and at first glance it would seem almost impossible for electricity to compete with present methods, owing to the great distances and the small amount of power used.

Three methods of power operation might be applied:

1. Air lift.
2. Gasoline engines.
3. Electric operation.

The first system was suggested by Mr. L. A. Hicks for the operation of the fifty-three pumps on the north of Poso Ranch. The plan was very ingenious in its conception and in the details which were worked out. He distributed compressed air from one central air station.

As for a comparison of the different systems, compressed air would be the simplest of all in its operation, but the first cost would be higher than either of the other systems. Gasoline engines would be the cheapest to install, but the most expensive to operate; besides, gasoline engines have a habit of getting out of order, and would require men of a comparatively great amount of skill, and hence well paid, to keep them in repair.

Electric operation was between the other two systems in first cost, being also very simple and cheap to run. Most of the country was open and level, and hence naturally suited for a pole line.

The system proposed was as follows: The present 10,000 volt line ending near Rosedale was to be extended to Wasco with 9x9 and 7x7 twenty-five-foot redwood poles. At Wasco, and at four other places, as shown on the map, were to be located transformer substations stepping down to 3300 volts.

Transformers of ample capacity for more than full load were to be installed. In addition, one twenty-five kilowatt transformer was to be kept on hand in event of losing any of the other transformers. The transformer substations were to be of wood, except at Wasco, where a brick generating station with one ninety-kilowatt, 3300-volt, sixty cycles, three-phase generator, one 100-horsepower engine and one 100-horsepower boiler were to be installed.

Current was to be distributed at 3300 volts, single-phase, to the different pump stations, where it was to be stepped down to 110 volts. The distribution pole line was to be 7x7, 5½x5½x22-foot redwood poles. The two 3300-volt wires were to run on a cross-arm, and the telephone wires below on the pole.

No. 10 B. & S. hard drawn copper wire was to be used for the extension of the 10,000-volt wires to Wasco. The wire for distribution at 3300 volts was to be No. 8 and No. 10 B. & S. hard drawn copper, and No. 8 and No. 10 B. W. G., E. B. B., galvanized iron wire; by far the greater part of the wire used being of iron. This, and the small size of the poles, cut down the expense of pole line very materially.

Line cut-outs were to be provided for every branch, besides having several in the main line. Lightning arresters were to be used at most of the stations. The telephone line was of two No. 12 E. B. B. galvanized iron wires, and a complete telephone system was to be provided. The equipment of each pumping station was to be as follows: One one-kilowatt transformer, one three-quarter-horsepower single-phase motor, one switch and fuse block, one automatic single-pole switch, operated by float, for operating motor, one telephone, one centrifugal pump to deliver thirty gallons per minute against a forty-foot lift. At each station was to be a small pump house. Where the water was sufficiently near the surface these pump houses were to be built above ground; but when the water was too far below the ground a pit about ten feet deep was to be dug and the pump placed in the bottom and belted to the motor above. There would be a foot valve on the bottom of the suction pipe, so that the pump would always be primed. The discharge would go into an earth reservoir. The capacity of these reservoirs was to be from 15,000 to 40,000 gallons, so as to have at all times at least a day's supply of water on hand, should any break occur in the line. Float valves would be put in the pipes connecting the reservoirs with the watering troughs. The automatic motor switch would be operated by the water in the reservoir. The reservoir would be fenced around the top to prevent cattle from entering. A low water alarm was to be put on the telephone circuit, which would ring up at regular intervals, the number of the station at which there was any such trouble. The oiling devices for pump and motor, would be of such a nature that they could run for days without attention.

In the stations where the water was very deep, where it would not pay to sink a pit, the pumps at present in use would be connected to a suitable power head and driven by double reduction belting and gearing.

While these pumps give a higher efficiency than small centrifugal pumps, where the lift is over twenty feet, still the power heads alone will cost from three to five times as much as centrifugal pumps suitable for this work; they also require much more attention.

Being unable to get a small runner suitable for a centrifugal pump, of high enough efficiency, the highest efficiency obtained from the small runners tried being 28 per cent., the writer designed a runner which gave 36 per cent. efficiency, a relative efficiency of about 25 per cent. better than the runner experimented with. This made it possible to use three-quarter-horsepower motors instead

of one-horsepower, and similarly made a very large saving throughout the entire plant.

The plant was to be operated by power from the Power Development Company's lines. Should any interruption of service occur, due to a break in the line, it could always be fixed up within a day. However, should any accident happen to the Power Development Company's plant, causing it to shut down, then it would be absolutely necessary to have a reserve station. With this in view, the Wasco power station would be put in. It might never be used, but if there ever was need for its use, it would be absolutely indispensable. It would deliver power to the pumps, fed from the transformers at Wasco, direct at 3300 volts. The step-down transformers would be used to step-up to 10,000 volts, and distribute back to the other substations.

Four men would be ample for the continuous operation of the entire plant. They would be expected to visit each station in operation, at least once in every two days.

The cost of installing the electric plant complete, would be $60,000. This includes the 120 miles of pole line, and 120 pumping plants. Each station was to have a motor, except on Poso Ranch, where thirty-five motors would be provided, the motors being moved around as required.

Figuring on interest on investment, and taxes, at 7 per cent., repairs, renewals and depreciation of pole line 10 per cent., repairs, renewals and depreciation of remainder of plant at suitable figures, the cost of operation, including the fixed expenses of the electric plant, would be of such a size that the plant would pay for itself in saving over present cost of operation within five years, and excluding depreciation and repairs, which would not cause much outlay for the first few years, the plant would pay for itself withing four years. In making this estimate the present plant has been credited back simply as junk, as it would be impossible to realize but very little on it. The cost of each station, pump, motor, etc., complete, excluding the reservoir, would be about the same as the cost of each station of the present plant, being almost half the total cost of the installation. It can readily be seen what a very large saving this would have made had an electric plant been originally installed.

With all pumps in operation at one time the maximum drop in the line voltage would not exceed 15 per cent. As the pumps would be operated, it is doubtful whether this would ever exceed 10 per cent. in actual practice, averaging perhaps 5 per cent. The cost of wire is so small that ample margin has thus been allowed for any increase needed. Single-phase is preferable to any other method of power distribution in such a case on account of simplicity. While there is little other demand for power in the district traversed, electricity renders possible a very simple and cheap means of obtaining power throughout the entire district, and use for it will undoubtedly grow, even though on a small scale, where the lines are at hand.

It is doubtful whether any other system could be as efficient or reliable under the circumstances as an electric system.

THE HYDRAULIC END OF POWER TRANSMISSIONS.

BY JOHN S. EASTWOOD.

IT will be impossible to begin to do a subject justice in a technical paper that would require a volume in itself, and hence it is the purpose to eliminate from this paper much matter that would naturally be retained in a more comprehensive treatment of this important subject. While there may be much in this paper that is not new to the members of this Association, it is because its membership is made up of the men who occupy the front rank in these subjects, and for that reason I beg their indulgence while introducing some matters that to them may seem elementary, but are necessary to a connected statement.

Water power transmission plants are made up of four distinct parts, each of which is in a way in a different class of engineering practice, viz., the hydraulic or water power, the electrical generating and controlling apparatus, the transmission lines and the distribution system. Of these four parts there is none that is subject to such wide variation as to character and cost as the hydraulic part, and hence none of more importance in its bearing on the total cost and ultimate practicability of the completed plant.

There are three classes of charges on works of this class, i. e., interest on cost, depreciation and labor supervision, all of which are much influenced by the character and cost of the hydraulic end.

The class of hydraulic works selected should be such that all three of these charges should be brought into equilibrium and as to give, at the same time, uninterrupted service. Again, the hydraulic works are made up of four different general parts, which are liable to wide variation, due to the physical situation and the engineering conditions to be met in each specific case.

These, generally speaking, are, the water storage works, the regulating works, the conduit, the pine lines, and the water wheels and tail race, each of which I will consider, not so much in a technical sense as in their general position and relationships to power plants, and some suggestions as to construction.

Before considering the subject of water supply and storage, I wish to make a few remarks about water measurements. We can scarcely realize the true value to the public of the work carried on by the Hydrographic Department of the United States Geological Survey, in the keeping of a daily record of the discharge of the various streams of the country during the recent drought periods, as they give engineers a positive foundation upon which to base their calculations for water supply.

These measurements are fortunately based on the unit of cubic feet per second, discharged, which by the way is the only rational unit for water flow measurement for power purposes. The miner's inch of California, or of any other State, being an orifice measurement, in which the character and condition of the orifice determines the volume discharged, conveys no idea of quantity until it

(Continued on page 116.)

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GEO. P. LOW, EDITOR AND PROPRIETOR

W. D. SHAWHAN, BUSINESS MANAGER

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EDITORIAL.

THE WORK OF THE CONVENTION.

Concurrent with the approach of each annual convention of the Pacific Coast Electric Transmission Association interest centers on the work which the gathering has in hand. Indeed, it is well that some event occurs to cause transmission engineers to pause in the strenuousness of their work and to reflect upon points which, not being pressing, are apt to be overlooked, yet the consideration of which is germane to greatest success. The days nor weeks nor months are not long enough for the engineer whose business crowds upon him in geometrical proportion, and who, if he would reflect upon his work of today in comparison with that of but a brief while since, would realize that the capacity of the human brain is not to be gaged by past or present accomplishments. Men are doing today that which was deemed impossible a year ago; men will do tomorrow that which is regarded as unthinkable today; but in this evolution of capabilities and in this development of possibiltties the mind of the engineer, and especially the mind of the electric transmission engineer, is loath to slacken its field work even for the consideration of matters having the imprint of fraternization or community of interest.

With the engineer, the solution of each new problem is found largely in an equation wherein local conditions are predominating factors, and so engrossed is he in his own work that he regards it as among impossibilities for him to personally undertake any serious labor "for the good of the cause." Noteworthy exceptions to this statement exist, as a perusal of the papers to be brought before the present convention will show, but in the main the truth is not to be gainsaid that it is easier for an engineer to lay out the details of a system having unprecedented features regarding head of water and voltage of transmission and complexity of distribution than it is for him to prepare a paper on, say, "Some Experiences I Have Had in the Operation of High Tension Transmission Lines." Not that he has not the ability to write such a paper, for his thesis when he took his degree shows techno-literary capacity of no mean order; not that he has not had abundant experience along the line indicated, for he is in possession of experience which has been had by no other engineer on earth in the operation of extremely high potential transmissions, and not that he does not want to tell what he knows, for at the lunch table, or during an evening at home, or while driving out of the power house, he will lay all before you—or before anyone else for that matter—like an open book. But when it comes to putting these self-same experiences down in black and white, or even in dictating them in the form of a paper, he is not to be depended upon. He does not seem to be able to bring his mind around to it; and all the world yearns for that which he is willing to give so bounteously, yet which he firmly believes he is incapable of doing. He will pierce mountains, he will tame cataracts, he will annihilate space, he will revolutionize industries, he will build cities, but he *thinks* it impossible for him to write papers.

An appreciation of these facts is held by the very few who have had to do with the affairs of deliberative organizations—that is, let us say in serio-facetiousness, with organizations like the Transmission Association whose members are deliberate in proffering papers. The first duty of the Transmission Association is a duty to itself, namely, to wake up in this the lateness of the morning of its existence. It has a field of operation which is the very crown of old Mother Earth; these Pacific states are the diadems, and to them the eyes of all civilization look yearningly. The Transmission Association was nobly conceived and its affairs have been creditably administered, but it has not reached the eminence of which it is deserving simply because of lack of interest among its members. This is not as it should be, and the rectification of this condition of latentness is among the first of the duties which is imperative on the present convention to perform.

It is noteworthy that while the majority of papers read before the San Jose convention were submitted by associate members of the association, the papers to be delivered to the present convention are not graced by a single one from the associate class of membership, which affords above all else the financial backbone of the organization. The present papers are all from the pens of representatives of full members, or from honorary members, or independent engineers. This is a sign of the times which is of good import, and it reflects the new energy which the worthy president has infused into the affairs of the association; nevertheless, it is regretable that no associate member has seen fit to contribute a paper, for the reason that most of the associate members, and especially those representing manufacturing interests, occupy positions which make them specialists, and, being specialists, their opinions and experiences are of the most valuable character, The idea that they have no interest other than a

self-interest, which is indistinguishable from ax-grinding salesmanship, is ungenerous, unbecoming and unwarranted, for every manufacturer today recognizes the fact that the general interests of the industry to which he caters are of far paramount importance to the interests of his own welfare if for no other reason than that the value of his own interests rise and fall in precise sympathy to those of the industry at large. They are in perfect synchronism, and cannot be pulled out of step without entailing disaster to one or the other member. Without exception manufacturers catering to the patronage of electrical transmission companies are all striving to gain trade by virtue of the intrinsic worth of their wares when viewed from the standpoints of economic efficiency, reliability and durability. The business of the manufacturer is to study the needs of the consumer and to supply his demands so far as they lie along the lines of each manufacturing industry, hence the cultivation of more intimate relations between the producer and consumer of materials common to transmission work is another duty of the association, and it is a duty which must not be shirked.

This suggests the idea that an exhibition of goods and materials, novelties, innovations and new ideas pertaining to transmission work should be made a prominent feature of future conventions.

It will fertilize our own transmission appliances with those of other progressive communities.

It will bring about closer relations between producer and consumer.

It will increase the associate membership list.

Why not?

Another matter which demands attention on the part of the present convention is that relative to the 3500-volt limit for city overhead pole lines as impends in an amendment which it is proposed to add to the Underwriters' National Code. This proposed amendment provides that no overhead electric circuit carrying wires having a difference of potential of more than 3500 volts alternating current between them should be allowed within seventy-five feet of any insured building. This means the prohibition of alternating current (why *alternating current* to the exclusion of direct current?) distribution at potentials above 3500 volts; it means that high tension transmission lines cannot pass through cities; it means the establishment of substations in remote outlying districts and the operation therefrom of heavy low tension distribution mains into the city; and it means, incidentally, the compulsion of enormous expenditures which are as unnecessary as they are unwarranted. It has taken years and years of labor to bring about amicability and united co-operation between the underwriting and insurance interests of the country—labor in which the writer has borne a more or less active part—and it is the wisdom born of experience which prompts the suggestion that it will be prudent to look further in quest of a means of reducing the hazards of high tension pole line circuits than to endeavor to eliminate it by its complete uprooting. Mighty as are the insurance interests of the country, the values represented in the electrical businesses reach far more stupendous totals, and these latter values are the ones to be affected by such a promulgation. All is peace and good will and harmony now; may it ever remain so. In the meantime let the Transmission Association note well that one of its time honored customs is in jeopardy; let it note that the recent convention of the National Electric Light Association unanimously passed a resolution condemning the proposed amendment as "uncalled for," and let it raise its voice similarly in expression of its views upon the matter.

One of the legitimate functions of the Transmission Association consists in the education of the industrial, financial and commercial public regarding the status of the power transmission business—its sturdiness, its permanency, the universality of its application, and, in brief, the exposition of its illimitable achievements and possibilities. The suggestion of this sphere of usefulness is due to Mr. E. J. de Sabla, Jr., president of the Bay Counties Power Company, and it contemplates the supplementing of the conventions of the association with popular lectures, well illustrated with stereopticon views, which shall be descriptive of the work accomplished by the transmission companies. To these lectures would be invited representatives of leading manufacturing, financial and industrial interests, and that the educational results so to be accomplished would redound to the utmost commercial advantage of the transmission companies is indisputable. The minds of men who are assembled in a convention for the discussion of problems which are mainly of a technical nature are sorely taxed when both day and evening sessions are devoted to engineering matters. Some recreation is necessary for the accomplishment of the best results, and this suggestion proposes that the evening session of the first day of conventions shall be devoted to the public along the line specified.

It is generally understood that the coming convention is to be conducted solely along lines of strict business, and in this it will be a departure from previous conventions—notably that at San Jose last year, where the social features predominated in a measure over the business ones. This convention will be marked as one of all work with no play, and whether it will prove itself to be laid along wiser lines than the former meetings, wherein some social relaxation was provided, remains to be seen. Were the will of the majority to be heeded, some social diversion would be provided—not social diversion of the "glad ragocricy," necessarily; but, for instance, such social diversion as Mr. de Sabla has suggested, or the social diversion of a banquet at the close of the session will be found to afford a middle course that will lead in the direction of most pleasant and most profitable sessions.

In conclusion, let it be impressed that the paramount duties of the present meeting are those looking toward the furtherance of the interests of the association, for its interests are those of electric power transmission itself.

THE HYDRAULIC END OF POWER TRANSMISSIONS.

(Continued from page 113.)

is assumed to be a certain part of some definite measure of volume, notably the California miner's inch is assumed as the one-fiftieth part of the cubic foot per second. The theoretical horse power of a stream may be determined by multiplying the head or fall by the decimal 0.1136, which gives the value in horse power for one cubic foot per second, and again multiplying this result by the number of cubic feet per second available.

In the storage of water for irrigation, owing to the desirability of knowing the amount of land a reservoir full would cover a foot deep, the acre-foot was taken as the unit of volume in water storage, being 43,560 cubic feet. The acre-foot fits in most admirably in power water storage computation in that from it we can, by discarding a small error, assume that two acre-feet will equal one cubic-foot day, or one cubic foot per second for twenty-four hours. This new unit of cubic-foot-days is a valuable one in computing the number of days and the number of cubic feet per second that are required to fill the low water gap, and the storage capacity required. The use of the gallon has no place in power storage computations and conveys no idea of potentiality, except where the storage is for domestic purposes, as in such cases the unit is the gallons per capita per day.

Water storage is taken as one of the parts of the hydraulic plant, for the reason that no stream can be assumed to have been developed to its true value as a power source, unless some portion of the water used is stored to fill the gap caused by an occasional dry year or drought period.

The value of stored water rapidly decreases as its volume increases, owing to the rapid lengthening of the period the volume is to be maintained, and hence this matter is one that resolves itself into one of cost per acre-foot for storage works.

The potential of stored water increases in proportion as the head increases, and hence the value of stored water increases with the head, or in other words, the higher the head the greater the proportion of the whole water supply can be stored water all of which is, of course, based on the assumption that the demand will be in excess of the low water flow, which is the almost universal condition on this Coast.

The class of works for water storage is largely a matter of natural selection, as dams usually can be built of the materials found near the sites, and the selection of sites is largely a matter of cost per acre-foot for the dams.

The most economical use of storage water requires a catching or regulating reservoir, which may be located at the head of the conduit, or anywhere along it to the head of the pipe line, but preferably at the latter point, as it is practically impossible to gauge the necessary quantity turned loose, unless the works are connected by telephone, which, in the case of high, numerous and widely separated sites, would be impracticable. The value of this class of storage can best be realized when it is considered in its utilities, first, as a reserve supply, in which case the conduit works can be built of such a character as would be unsafe without it, and the capital investment in many cases very materially reduced thereby; second, as a daily storage supply, enabling a full load to be carried on a reduced daily flow, in which service alone it will be seen to be more valuable than any other class of storage, and last, it serves as a settling basin for removing the remaining grit from the water.

As to conduits for conveying the water from the stream to the point of use, the class to be selected depends to a large extent on whether relay storage is possible or not, on the character of the supporting ground, the proximity and cost of construction materials, the climatic conditions and the volume of water to be conveyed.

There are valuable side lights thrown on the engineering features of this class of works by the experiences gained in operation during an extended period. It will be found, as a general rule, that the cost per lineal foot of conduit will classify them in about the following order: earth canal, wooden flume, stave pipe, paved canal, steel pipe and cement lined tunnel. Assuming relay storage possible, the character of the conduit works should still be selected on the basis of total running cost, consisting of interest on investment, depreciation and labor supervision. I am satisfied that if this method of determining the class of works to be adopted is used, the conduit will consist of some one or other of the more expensive types, for it seems to be a safe rule that the less the first cost of a conduit, the more the maintenance costs will be.

For instance, earth canal on mountain slopes requires constant and vigilant watching to prevent expensive breaks by burrowing rodents and storm waters, and this labor item and the repairs will be found, in most cases, to more than pay interest on the cost of paving and cementing the canal bottom throughout. The interruption and destruction of flumes by rocks loosened from steep mountain slopes, coupled with the rapid decay, placing them as the shortest lived of any of the classes of conduits, will show a flume to be a very expensive conduit in any case.

The depreciation, owing to the rapid decay of the materials, and the added cost of removal and replacing decayed parts in flumes, is over 15 per cent per annum. Thus it will be seen that in adopting some other style of conduit, a capital investment of four times the cost of a flume could be made which would, in nearly every case, furnish a class of works in which the maintenance costs have been largely eliminated, and the total charges minimized.

It will be found that, in nearly every case, the added original investment charge to eliminate the maintenance charges will not exceed the sum of the charges in the first instance, thus showing a saving while at the same time maintaining continuous service, the value of which it is hard to overestimate.

Under this line of investigation, and keeping in mind

the necessity for continuous service, the tendency is toward the construction of a better class of works for this service.

As a general rule, guiding the selection of works for conveying small quantities of water, paved and cemented canal, using stave pipe or steel pipe inverted siphons for crossing depressions, will be found economical construction. For large quantities of water, paved and cemented canal for flat slopes and cement lined tunnel and siphon tunnels for rough country will prove most economical.

It is a regrettable situation, but one that must be met and remedied, that the reputation for unreliability long distance power transmission has in the public mind, is largely due to the flimsy character of the hydraulic works of power plants. It is my opinion, based on observation and experience, that if the same skill and care were used in the design and construction of the hydraulic works and transmission lines that is used in the apparatus furnished by the electric manufacturing concerns, accidental interruptions would be almost unheard of occurrences.

An important feature in hydraulic conduits for power purposes, and one that becomes more important as the head increases, is the provision of sand traps for removing automatically the sand from the conduit and delivering the water to the pipe line free from grit. In situations where relay storage is not practicable at the head of the pipe line, a settling basin, consiting of an enlarged section of the conduit, without grade, should be provided to remove such gritty matter as passes the sand traps in suspension, as the saving in the wear of apparatus will justify a considerable outlay for this purpose.

During the past year some quite novel ideas have been advanced in the design of pressure conduits, the importance of which, in advantages and economies, becomes more apparent as the size of the installation increases.

This is the adaptation of the tunnel and shaft, or incline tunnel, to the conveyance of the power water under pressure from the end of the grade conduit to the distribution pipes, making the walls of the tunnel furnish the strength of the conduit, relying on the lining to make it impervious.

Owing to the great cost of steel pipes of any considerable capacity to carry water under high pressure, the place in the size of installations where this method will be cheaper than steel pipes is found to begin in even moderate sizes, and as most all of the proposed sites, where high heads are contemplated are in such places as are adapted to this class of construction, by reason of the character and condition of the country rock, it is a subject well worthy of closer consideration by hydraulic engineers contemplating the design of hydraulic works of magnitude. Some of the advantages of this plan will be found, first, in the enormous saving in first cost as compared with steel pipe lines, the difference increasing rapidly as the quantity of water to be conveyed increases; second, the absolute safety and the entire elimination of depreciation and maintenance charges; third, the reduction of the friction head and consequent increase in efficiency of the water; fourth, the ease of distribution of the water to the separate units without losses due to cramped areas and sharp turns.

This idea of pressure tunnels is but the amplification of one that has impressed itself forcibly on the mind of the writer, and which I am sorry to say has not been given due consideration in some later built plants, and that is, that it is impossible to lay the pipe line two deep in the trench.

The advantages of deep laying are three fold, as it increases the strength of the pipe equal to the weight imposed, making it impossible to collapse it by vacuum drawing; it prevents expansion and contraction due to changes in temperature, one of the most serious sources of trouble, and it prevents the shifting or slipping of the pipe line.

Under extremely high heads in moderate sized plants, one of the problems to solve is the division of the pipe line to convey the water to the separate wheel sets.

There is great divergence of opinoin as to whether the method of bifurcating the pipe or that of placing a cross head or receiver at the lower end of the lines is the better practice. The use of a receiver or enlarged section at the lower end of the pipe line has been discontinued as being not only useless for the purpose for which they were originally designed, but as tending rather to lower the efficiency of the water than otherwise.

A little thought will convince one of the fallacy of bringing the water to a dead rest, only to hurl it at nearly full spouting velocity at right angles through a sharp cornered orifice. The ideal conditions are as straight a flow as possible, with a gradually increasing velocity from a point near the end of the pipe to the point of discharge at the nozzle tip.

These conditions can best be attained, with the high velocities now adopted in main pipe lines, by the method of dividing the pipe into branches, where anchorage can be secured at the junctions to prevent longitudinal movements.

In speaking of water wheels, I shall confine myself to suggestions of arrangement, as it is at the end of the pipe line that the work of the civil hydraulic engineer ends, and that of the mechanical hydraulic engineers, the makers of the water wheels and fittings, begins, and as this apparatus as well as the generating machinery is usually furnished under guarantees, there is not the chance for wide difference in the character and value of the completed works that there is in the purely hydraulic end. For this reason it is apparent that it is the part of wisdom on the part of the prospective investor in power transmission plant construction to employ such men for this branch of the work as have been especially fitted therefor by an intimate knowledge, acquired by experience and special study of this engineering specialty.

The water should be carried to the wheel with only sufficient slope to drain the pipe line and tail race, and

the tail race should be simply a discharge tube, as in high head work it is folly to attempt to intercept the water after it leaves the water wheel.

When it is borne in mind that in any power transmission project the portion of the works from the end of the pressure conduit to the distribution of the current, is a simple proportion to the size of the plant of the materials required, and that the hydraulic end, subject as it is to the widest possible variations as to its cost and value, is the true criterion on which to base the selection of a power transmission site.

At this point I will ask the further indulgence of the members of this Association, while we take a little side trip, and have a glimpse of what may be justly termed the pyrotechnics of the hydraulic end, suggested by a somewhat close intimacy with this feature of this subject, and when it is taken into consideration that the modern tendency is all towards the development of higher heads, owing to the fact that we have not yet utilized in practice such a height of head as to determine the point where the cheapening influence of such increase has been felt to cease, this portion of my paper may contain more potent matter than would at first be apparent.

We are led to look upon water, in its everyday condition, as a simple liquid that flows along with an easy rolling motion, due to the easy slipping of the particles of its mass over each other, and so it is, but, when we confine it in a pipe and increase its velocity of discharge, we change certain of its characteristics in varying degrees as the pressure and consequent velocity increases.

One of these phenomena, for such they may be termed, is that water, confined or not, tends to take up a rotating motion, which, in combination with its onward movement, makes a whirl or twist in the stream. Don't ask me why, but I will suggest that it is always in the same direction, and the same direction, too, that nature twists things, the climbing vine, the twisted tree, the snail's shell; but that's another story, as Kipling says, it's one of God's laws of nature. Another is that water tends to form itself into filaments or points of energy, the size depending on the velocity and volume, which follow the laws of solids in rebounding at the angle of incidence. These filaments, striking the sides of a tapered nozzle tip, will rebound, through and among its fellows, and striking the opposite side at a sharper angle, owing to the taper, again rebound, after gouging out the particles of metal near the lip, and issue from the nozzle, each one attempting to cross the path of the other, a jet of froth, when released from confinement.

It was owing to this fact that a narrow ring, placed a short distance from the tip, in fire hydrant nozzles, was proven most efficient in a series of tests, the ring tending to prevent the rebound of cross currents.

It was to correct these two motions and bring the water back to the straight line of duty that the needle nozzle was invented, and I doubt if a more efficient piece of apparatus for this purpose can be devised.

Again, as the pressure increases, water partakes to a corresponding degree, of the nature of a solid, and must be handled as if it were a projectile or volley of projectiles, which nature it assumes, and the apparatus must be so designed as to meet these altered conditions. Thus, of the two forces acting on a tangential water wheel, i. e. the impulse and the impact, the latter is increasing and the former decreasing as the velocity increases, by reason of this approach to the law of solids in motion, and hence the curves of water wheel buckets must be changed as the head changes, to get the best results from the water, as well as to make them able to withstand the heavy and frequent shock.

When we contemplate using water under a head of say 4000 feet, we have a spouting velocity of over 500 feet per second, or one-fourth the muzzle velocity of a cannon ball, and to withstand the blow that would be given by a stream with such a velocity, the water wheels would surely need to be built for business.

The cutting or scouring effect of even clear water increases very rapidly as its velocity increases, so that apparatus for handling water under high pressure should be so designed as to not pass the water around sharp edges or to strike any surface at a sharp angle. Among other things to avoid are sliding contacts, as they become seated and are hard to work, the use of any device for relief, but shock should be made impossible by means of slow moving and positive acting opening and closing devices.

The theoretical point where the increase in head would cease to be a benefit would be where the increase in cost of the supply pipes and water wheels offsets the saving in the storage and conduit works, assuming the water efficiency as remaining the same, but I am inclined to think that the point of limitation will be where, by reason of the peripheral speed of the water wheels, the elastic limit of the materials is reached long before the other point is met.

The Swiss are developing a head of 3150 feet near Lake Geneva, which will be watched with much interest, but I feel assured that we will see the day when even that head is exceeded in California.

While there are many features of much interest, connected with the hydraulic end of power transmission plants that have not been touched on in this paper, owing to lack of space, and possibly, the patience of the members of this Association, I will feel well repaid if, in this ramble in some of the byways of this important subject, I have been able to furnish food for discussion to some of those members who may be in a position to benefit thereby.

CLOUD VERSUS COAL.

BY ALEXANDER G. McADIE.

THREE hundred and twenty-three years ago (1579-1902) an intrepid sea captain hauled his little craft ashore for much needed repairs, on the beach a few miles north of San Francisco. Half way round the world had he sailed that little "Golden Hind," and he was then studying the problem of getting home by sailing farther west. Note

the word sailing. Francis Drake and his rough-and-ready crew did not propose to tug wearily at the oars, if they could utilize the energy of air in motion, commonly called wind. But if Drake could revisit Point Reyes to-day and see as we can see the Wisconsin, the Iowa or the ever-ready Oregon steam out past the Heads, surely his feelings would o'erpower him. "The men seem to be flesh and blood and human, but that great white leviathan, 'tis a dream; or else 'tis magic!" we can hear him say. Yet Drake and his men must have looked at the clouds and many a time watched the unending procession of these fleets of the atmosphere. It never occurred to them that in the birth of a cloud a great physical process is at work and that in the centuries to come men of their own race and kin were to harness the expansive power of water vapor and by its aid drive the cylinders and screws of ships, the wheels of locomotives and in a thousand and one ways make this mighty servant, steam, do their bidding.

And we, too, are looking at the clouds, admiring their grace of form and poetry of motion, and all the while blind to the significance of cloud formation and dissipation. A coal mine is valuable because it represents so much stored energy. We can burn coal and utilize the heat of combustion. At first glance it would not seem that a cloud could be thus utilized. Coal is the long ripened vegetation of prehistoric ages. Vegetation depends on sunshine and shower. Water is the most abundant ingredient of the plant. It may be rather a novel comparison—this of the fleecy cloud and the gray fog bank to the sooty coal—but the difference between them after all is chiefly one of degree. In the case of the coal the sunshine falling on the leaf causes chemical change and is buried for long ages underground; or else in the woody fibre of the tree is used without so long a delay. With the cloud the heat of vaporization supplied by the sun is set free by the condensation of the water vapor as rain, and while much energy is spent at large, some of the solar energy which lifted the water from the sea surface to the mountain crest comes back to us in the head which the mountain streams have, and this, the electrical engineers of our time, of our State, yea, of our Transmission Association, are harnessing skillfully and rapidly.

Not long ago Mr. T. C. Martin, calling attention to the rapid extension of long distance power systems in California, commented on the compensatory plan of Providence which gives the British Islands coal beds in lieu of sunshine, and California more sunshine than coal. Mr. Martin continues:

"Whether it is better for a country to live on its geology or its geography has remained hitherto a moot question; but usually coal mining regions have little to recommend them as places of residence after the deposits are exhausted. Newcastle and Pittsburg have no vogue as pleasure resorts; but long after their pits and volcanoes of pent up energy, hushed and empty, lie in black silence, picturesque Switzerlands and Californias will be drawing cheerfully upon the renewed bounty of the daily blue sky and fleecy cloud. The chief future of China appears to consist in its supply of black coal; but when that, in turn, is worked out, the melting glaciers of the Jungfrau, the bubbling streams of the snow clad Sierra, and the rushing tide of the Niagara gorge will still be here to give up to us, not alone their beauty, but their strength. It is doubtless satisfactory to know that if you want warmth and light you can dig it up; but when the digging of the black coal dwindles, hand-to-mouth diurnal dependence upon sunshine and showers for the 'white coal' that must largely take its place will be a mark of the highest economy and best efficiency of our engineers."

We would call attention to Mr. Martin's allusion to the bounty of the blue sky and fleecy cloud. California faces the Pacific Ocean. The long stretch of the coast line of the State, in length corresponding to that portion of the Atlantic seaboard between Boston and Savannah, breasts the ever moving stream of air from west to east in these latitudes. This steady easterly drift of the lower air means a ceaseless conveyance of large amounts of water vapor from ocean surface to the mountain side. The streams of the Sierra have their birth in the condensation of this water vapor, and thus in a way more direct than any other known at present, the heat of the sun is utilized by man. There are but two intermediate steps in the operation; first, the evaporation; and second, the condensation. Thus the cloud and the fog are simply agencies for storing and conveying solar energy.

What a modern Proteus is water! We meet it in the atmosphere as mist, fog, cloud, hail, snow, sleet, frost, dew and rain. It can work mischief to man as well as benefit him. Uncontrolled and seemingly uncontrollable, mark how it sports with the labors of our hands. In the "Electrical World and Engineer" of March 29, 1902, page 838, one reads:

"The damage inflicted upon overhead wires by the sleet storm of February 21st exceeded previous records. For several days Philadelphia was telegraphically isolated from the rest of the country as completely as though invested by a besieging army. Baltimore was in nearly as great a predicament and even New York was crippled in its telegraph communication with the outside world. Such a condition has not been confronted for half a century." The comment to be made upon this is "much good energy running riot."

The problem of the engineer of the next decade is the utilization of natural forces. There are some engineers to-day, John Perry and others, who foresee a limited coal supply. Modern civilization requires vast amounts of coal. Seven hundred million tons per year hardly suffice. And while of course much goes for heating directly, it is worth noting that even the best steam engines utilize less than 10 per cent. of the energy of the coal. Now, all the wood, coal and peat in the world came from the action of sunlight on the chlorophyl grains in the leaves of plants, working, according to Storer, "to decompose the carbon dioxide of the air." With the cloud

there is no intermediate chlorophyl. And owing to its high specific heat what better medium is there than water for the storage and transportation of heat energy? But how to utilize directly the energy of the cloud—there's the rub. A rain drop and a flash of lightning seem to be far removed from one another; but that is only because we know so little about the rain drop. The man who shall solve the problem of the formation of the rain drop, I mean the physicist who will tell us the full story of the play of the ions, as the water vapor is beginning to condense, will tell us also where the electric charge comes from, which is made manifest in the varying potentials of the air, the wonderful beauty of the aurora, the silent St. Elmo's fire, or the fierce impulsive rush of the lightning flash. With equal patience and surer hope than that with which Watt and his followers studied the expansive power of water vapor, shown in so homely an experiment as the kettle on the hearth—the aerophysicists of to-day are pushing forward their investigations on the electrification of the air. Already foreshadowed in the play of the ions as nuclei of condensation, we know that the time is not far off when he marvelously delicate processes at work in the formation of a globule of fog or a drop of rain, will be made plain; and even more potent than the expansive power of water vapor, and equally obedient to man's bidding, will be the excursions of the electrons hurrying to and fro.

ELECTRICITY AND THE LAW.

BY FRANK P. MEDINA.

IN every country the social institutions act and react on one another in such a way as to affect growth and development. Whatever characteristics the prevailing mode of social activity impresses on the regulating structures, these characteristics influence the evolution of the structures regulated. For instance, where the governmental activities are strongly militant, the institutions engaged in the work of sustaining the society, themselves take on a regimented character. In other words, the various institutions that make up a nation are related to one another in a manner very similar to the organs of an organism.

It is not to be understood that the so-called regulating structures are alone in their influence on social structure in general. It is just as true that the operative structures affect the regulating structures and tend to modify them in conformity with the social necessities.

So the lesson of history teaches that the part of the operative structures called industrial, and the part of the regulating structures called legal, mutually react on each other. The wants and fears of men create them both, and the same wants and fears create the correspondence between them.

The size and importance of an industrial institution are great factors in its influence on the laws. A glance at the state of the common law in the feudal period, when ownership of land practically filled the legal consciousness of property, and at its state when the growth of commerce made personal property more nearly its dominant object, sufficiently shows how closely the characteristics of our laws correspond with the growth and development of an institution which they are designed to regulate. To-day the laws are construed with direct relation to commerce, public policy is directed by regard for it, contracts are interpreted, the laws of descent are restricted, and all the activities of mankind are regulated from motives having their roots in this great institution.

The growth of industries based on various applications of electricity is rapidly bringing them into the front rank of social institutions. The billions of dollars already invested, the enormous number of people directly and indirectly involved, are making electrical industries an institution of the greatest importance, and causing them to occupy a space in the social consciousness second to none.

As the growth of commerce had its effect on jurisprudence, so is the growth of electrical industries having its effect. Its influence may be seen in the great body of statutory law enacted during the past quarter century, regulating the employment of electricity. Witness also the vast number of decisions now extant relating specifically to electrical industries. It has become common to regard the Law of Electricity as a special branch of our general jurisprudence.

The sources of electric law lie in the fundamental doctrines of law and equity. Most of these fundamental doctrines, the results of ages of social experience, are too close to the ideal of natural justice ever to change very much. But the application of these doctrines to a society without electrical industries is a very different matter from their application to a people amongst whom electricity has become a prominent social factor. The rise of electrical institutions has modified their application and will continue to modify it, as the new institutions grow in mass, number and variety.

There are three modes of adapting fundamental legal rules to new conditions: by what are called legal fictions, by adjusting them on principles of equity, and by legislation. Legal fictions were much used in ancient times for this purpose, but the modern love of truth and common sense have caused or is causing their abandonment.

The wider the generality of a doctrine, the more closely becomes the restriction of its fitness to average cases. Cases involving circumstances that give them a nature considerably different from the average may not be included in the general doctrine without great injustice. Hence, arose equity, which corrected the application of the general doctrine in "that, wherein the law, by reason of its universality," was deficient.

But the modern mode of adaptation is by legislation. Through the legislatures of the United States the status of the various electrical industries is becoming fixed, and their relation to the other social institutions and amongst themselves is being more and more clearly defined.

It would be very interesting to make a general com-

parison of the modern application to particular cases of the old rules as modified by legislative enactment, and, as viewed by the courts in the light of modern ideas, with their ancient application to analogous cases, but the limits of this paper forbid it. With special reference to electricity we might note the modification in the law of contracts which makes them valid when made by telegraph or telephone, being a condition of making a contract in which the contracting parties contract neither in the presence of each other nor by writing "signed by the party to be charged." Yet valid contracts, each involving thousands of dollars are daily made in this manner.

We might further note the modifications introduced by electricity in legal practice as witnessed by such proceedings as service of process by telegraph. It is a matter of common occurrence for writs of summons, subpoena, attachment, injunction, to be served in this manner, that is, by service of a telegraphed copy instead of the original writ.

The limits of this paper permit little more than a bare reference to legal questions relating to the telegraph, telephone, electric railway, light and power industries themselves. Their legal relations to one another and to other industries are becoming defined with increasing precision. Some particular legal principles may, however, be touched upon as of special interest.

An electrical company undertaking to do business usually does so under a grant. Now, those whose interest is affected should see to it that this grant is very carefully drawn; for an electrical company "acquires no privileges not directly specified in its grant, or which follow as necessarily incident to the construction and operation of its lines in accordance with the terms of such grant." An instance is given of a telephone company which was granted the right to string its wires across streets and along the tops of buildings, subject to the consent of the owners thereof. It was decided that such right should not be extended so as to confer upon the company the right to erect poles in the streets unless the city consents in express terms thereto.

The power to grant franchises is confined to the legislative branch of the government and does not belong to local governing bodies. These bodies have power to regulate the exercise of the right conferred by the franchise, so far as its exercise affects their local jurisdiction, but the power is confined to reasonable regulation, and does not extend to the right to exclude. And when a local governing body has granted an electrical company the right of the use of streets and the company has constructed its line in compliance with and reliance upon the conditions of such grant, the grant cannot be made the subject of new conditions aside from what may be necessary in the proper exercise of police power and control and regulation of streets.

These matters, however, are not altogether within the scope of the present paper, nor are such matters as the relations of electric corporations to their employes, interferences between the wires of one corporation and those of another, or questions of liability for negligence arising from imperfect insulation. The fact that a large body of decisions exists covering all these matters is sufficient to illustrate the propositions to which it is desired to call attention: That the institutions of a society act and react on one another; that the force of their reaction is in some way proportioned to their mass; and that electrical industries, as they grow in importance, react on jurisprudence in greater and greater degrees. So that we may expect in the future to see our laws so modified that, for instance, the successful working of an electrical concern of the greatest public utility may not be interfered with by undue regard for the safety of a few shade trees on the public highway.

AN 80,000 VOLT TRANSFORMER.

IN December last the General Electric Company was asked by the local lighting and power company in Butte, Mont., to submit a bid on a transformer to enable them to utilize 1200 horsepower at 80,000 volts from the Madison River Power Company. While the company stated that they did not consider it the best of engineering to use so high a voltage for a transmission of only about 60 miles, it was quite willing to undertake the work, and promised to deliver the transformers in fourteen weeks, an exceedingly short time considering their size (330 kilowatts), and a great advantage in voltage over commercial transformers previously built. The work was accomplished, however, substantially in the promised time and without an evidence of any weakness in the design as originally laid out.

In general the design closely follows the standard oil immersed water cooled transformer built by the General Electric Company, and except for allowance for the increased voltage is identical with that of the 500 kilowatt transformers built by it for the Piedmont substation of the Bay Counties transmission in Oakland, Cal., which have now been in continuous operation for over a year at 45,000 volts.

The coils of which the winding is composed are wound with flat copper strip and are remarkably strong and rigid considering the small conductors that must be used for such small high voltage units. They are covered with only sufficient waterproof insulation to exclude any moisture that might be deposited on them during transportation. The heat generated in the winding can therefore escape as easily as from the coils of a low voltage transformer.

Oil, specially refined for this high voltage work, is relied upon mostly for insulation. The spaces between the high voltage coil and all other parts, however, are subdivided into separate ducts by diaphragms of solid insulation, so that any conducting particle that by accident might fall into the oil can bridge but a small percentage of the oil space. This construction, it will be seen, also subdivides the solid insulation into thin layers, so that any heat that might be generated in it due to dielectric hysteresis is promptly dissipated by the free moving oil in the ducts.

The transformer case and cover, including all bushings and cables, are made with air tight joints. Previous to filling the transformer with oil it is exhausted of all air with a vacuum pump and the winding heated to expel any moisture that might be on the coil surfaces. While in this vacuous condition, oil specially treated to expel all foreign particles, air or moisture, is allowed to flow into the transformer from the oil treating tank, this method of filling being repeated when the transformers are started in commercial operation.

By the use of these novel methods the insulating quality of commercial oil is so improved as to require much less thickness of oil to withstand these high voltages than would otherwise be the case. Reduction in transformer costs and improvement in its constants are the natural results.

Tests showed the following performance at 60 cycles: Efficiency, 97.5 per cent.; regulation, 1 per cent.; reactance, 4 per cent.; heating by resistance, 30 degrees centigrade.

When the small capacity and high voltage are considered, also the fact that the greatest reliability rather than extreme efficiency, etc., was especially aimed at, these figures prove that 80,000-volt transformers are an assured commercial success. The test included an insulation test at double voltage, namely, 160,000 volts, which failed to develop any weakness.

To determine the possible presence of losses due to dielectric hysteresis or actual leakage through the oil or other insulation at this very high voltage, transformers were excited to double their normal voltage on the low potential side. The losses were then measured with the high potential windings separated into several sections so that the maximum voltage generated was so low that no such losses could take place. The high potential windings were then connected in series and the losses again measured. They were found to be identical with those first observed, indicating the entire absence of any such losses.

The terminal cables have soft rubber disks projecting from them. These were necessary in order to break up the static discharge that took place over the surface of the insulations when the transformer was under a strain of 100,000 volts between winding and ground. The insulation on these cables was ample to withstand this strain, but the static charge on the surface was so heavy as to reduce the effective length of the insulation to but a small fraction of the actual length. The test potential would cause an arc to form between the uninsulated end of a cable five or six feet in length and the transformer tank, before the soft rubber disks were added. The rubber was so molded that it could be securely cemented on the insulated cable for a distance of an inch or more. The disk, therefore, served the purpose of breaking the continuity of the static discharge and prevented the short circuiting of the test voltage. At operating voltage there was no brush discharge whatever; consequently the disks were useful only in connection with the test.

These transformers have now been in continuous operation at Butte, Mont., for several months. Unfortunately, however, the Madison River Power Company is not yet ready to deliver current at higher than 40,000 volts, so that the possibility of transmitting such voltages with the present methods of line construction has not been demonstrated "out in the open."

AN EXPERIMENTAL ELECTRIC FURNACE.

AN European electrical contemporary of recent date* contains an illustrated description by Dr. L. Liebmann, of a laboratory electric furnace which he has used for some months, with most satisfactory results, for all kinds of electric furnace work. The furnace body is built up of the two types of moulded blocks shown in Figure 1. The larger blocks, marked A, are made of the best fire clay, and in Germany are sold for about 9s. the couple. It is advisable to obtain them with a slight dip towards the center of the hollowed-out portion, in order to retain any molten matter that may escape from the inner furnace. When the heating is carried out in these larger blocks, they should be lined with magnesia to protect them from the direct effects of the arc or molten mass. The smaller blocks (*a*), are obtained by splitting with a chisel the ordinary stoneware ducts, sold for enclosing electric cables. In Germany these are known as "Normalkabelsteine." They can be easily split into two equal halves, and are very cheap. These smaller block are not manufactured of specially heat-resisting materials, but their solidity is sufficient to resit one heating in the electric furnace, and they are so cheap and so easily obtained, that new ones can be used for every experiment. It is advisable not to warm these blocks, and to coat the interior with magnesia before using in the furnace. Figures 2, 3 and 4, show various methods of arranging the carbons in these channeled blocks, and Figure 5 shows the complete furnace arrangement, with the leads and the water resistance for varying the current used. The author states that he has used this type of resistance since 1894, with the best results, and that both continuous and alternating current can be regulated by it with the greatest ease. In his experimental work the town supply of alternating current at 120 volts has been employed, and it has been necessary to reduce this to 60 volts for use in the furnace. This reduction has been effected by the resistance shown in Figure 5, without difficulty, and currents up to 250 amperes have been passed through it. The following are the advantages claimed for this type of laboratory furnace:

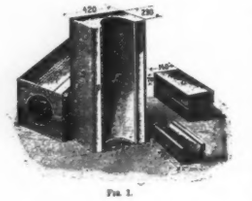

FIG. 1.

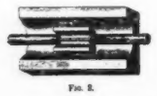

FIG. 2.

FIG. 3.

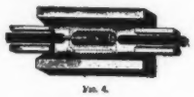

FIG. 4.

FIG. 5.

1. The furnace is always ready for use, either for arc or resistance heating.

2. The furnace can be used without difficulty or delay, either for heating small or large amounts of material; 20 grammes or 15 kilogrammes are the extremes of weight dealt with by the author.

3. The furnace is remarkably cheap to construct, and in this respect compares most favorably with the original types of electric furnace designed for laboratory work by Moissan and Borchers.

4. The furnace permits the heating of the substance to be carried out in any desired atmosphere, by the use or non-use of the channeled blocks, for covering the carbons and heated substance.

5. The furnace allows close observation of the progress of the heat reactions.

6. The furnace permits the use of currents varying from twenty to 1000 amperes in intensity.

Dr. Liebmann has used this type of furnace for the laboratory production of calcium carbide, ferro-silicon, chromium, chrome-copper, molybdenum and of phosphor-copper alloys with most satisfactory results.

*Zeitschrift fur Elektrochemie, February 27, 1902; reprinted in *The Electrician*, London, Volume XLIX, page 46, May 2, 1902.

A NEW PROPOSED SAN FRANCISCO TRANSMISSION.

The latest large electric power project in California is one in which E. T. Earl and his associates are interested. According to a statement of James D. Schuyler, the company's hydraulic engineer, it is proposed to install an electric transmission plant in Plumas County, whence current will be transmitted a distance of 180 miles to San Francisco. Water appropriations of 120,000 miners inches of the waters of Feather River and Butte Creek have been filed. The Big Meadows reservoir will have an extent of 8000 acres, and the other in Butte Valley, a few miles distant, will cover 2000 acres. From the reservoir in Big Meadows it is expected to construct a canal about ten miles in length to the Butte Valley reservoir, whence the water will be conducted along the edge of the Feather River canyon by a series of tunnels for a distance of five miles. At this point on Mosquito Creek the water will have a vertical fall of 1600 feet, giving an estimated total of 270,000 horsepower. The Western Power Company, with a capital stock of $5,000,000, has been organized in Los Angeles to handle these properties.

Among those interested in the company are Edwin T. Earl, founder of the Earl Fruit Company, and Geo. F. Batchelder, vice-president of the banking firm of E. H. Rollins & Sons, of San Francisco and New York.

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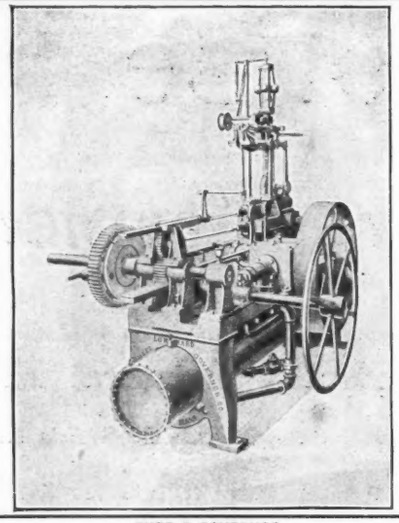

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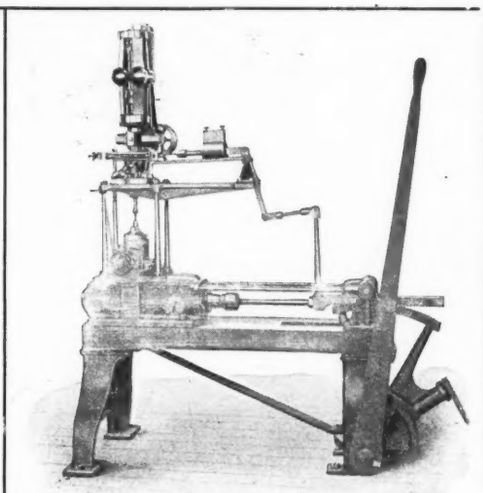

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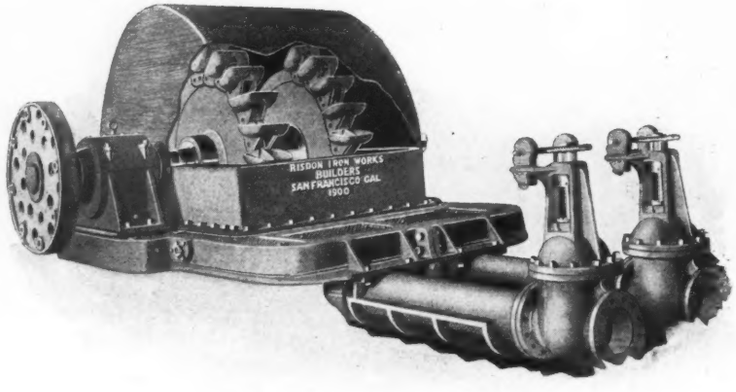

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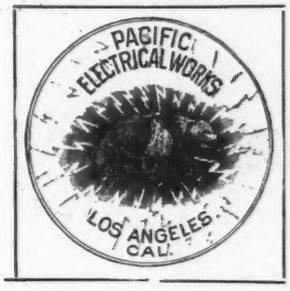

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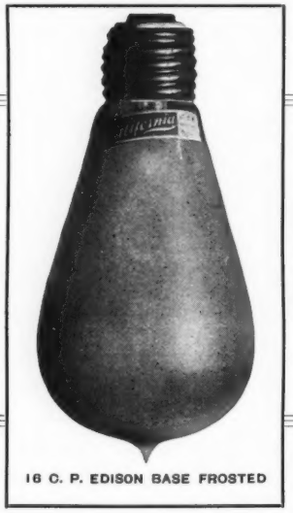

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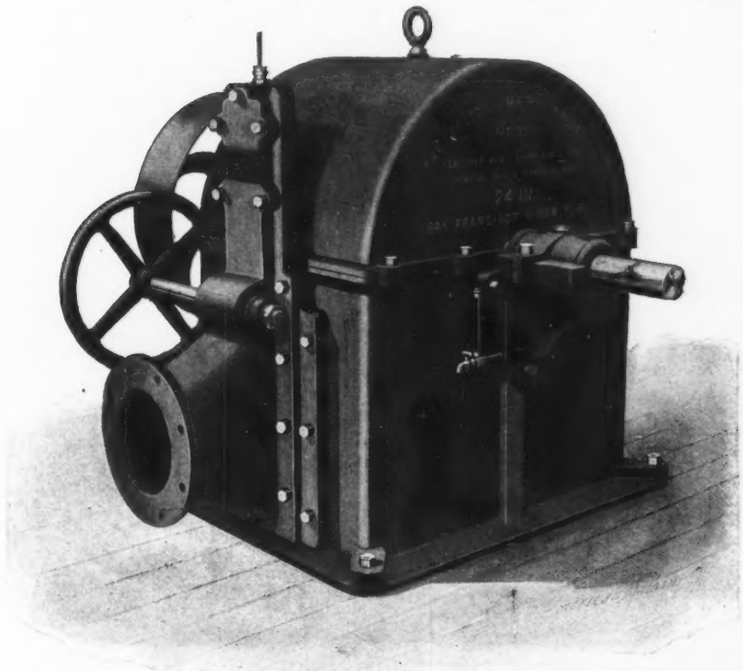

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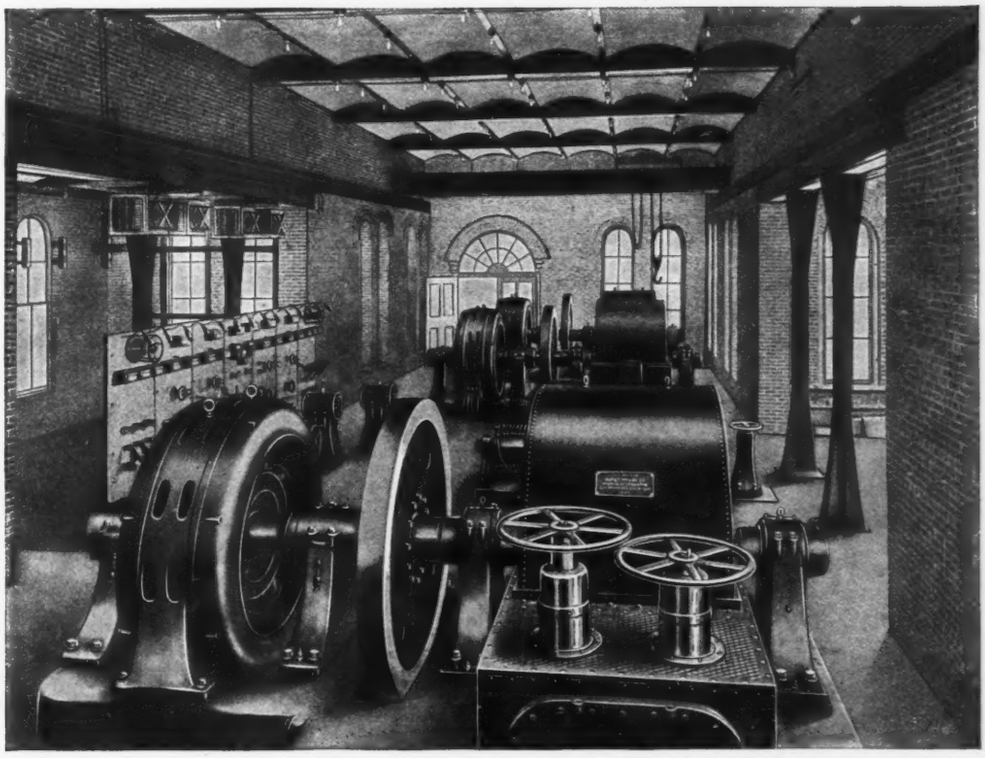

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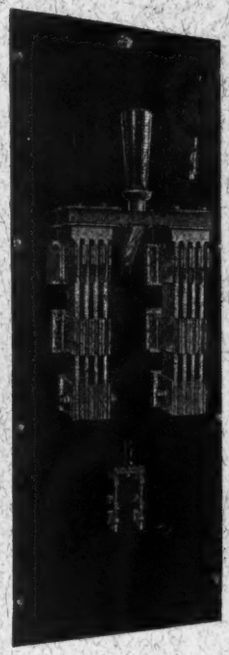

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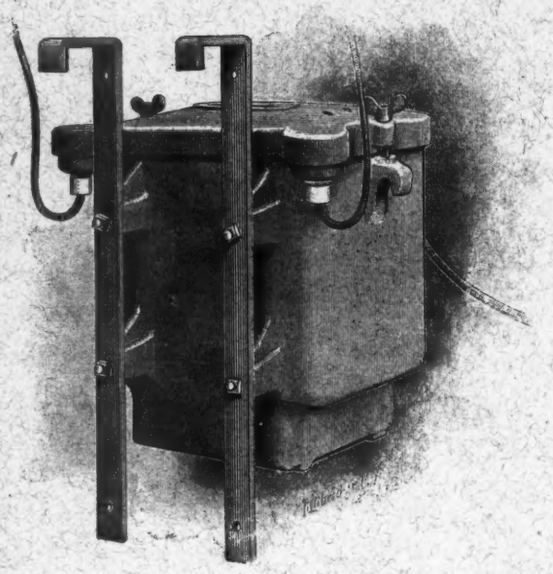

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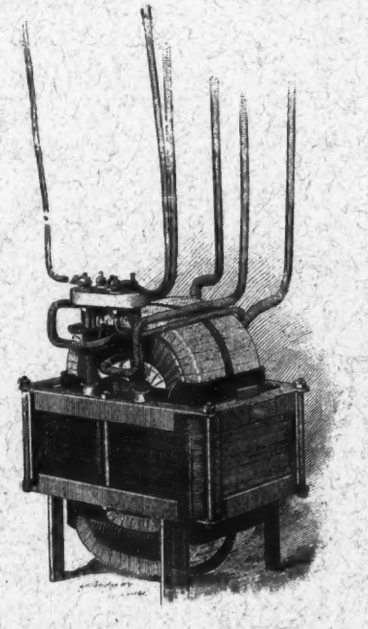

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